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Assessment of the Recovery Potential for the Outer Bay of Fundy Population of Atlantic Salmon (*Salmo salar*): Status, Trends, Distribution, Life History Characteristics and Recovery Targets

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

As a part of the Recovery Potential Assessment process that was triggered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designation of Outer Bay of Fundy (OBoF) Atlantic Salmon population as 'endangered' in 2010, this document updates the status, trends and life history information that were last provided in Jones et al. (2010) for the COSEWIC (2010) review. New information related to the current range, distribution and densities of wild origin juvenile salmon from an extensive electrofishing survey completed in 2009, and the abundance and distribution recovery targets for Designatable Unit (DU) 16 are also presented.

Adult salmon counts and estimates of returns to counting facilities (e.g., fishway, counting fence) and subsequent spawners are evaluated against conservation egg requirements that were determined for each index river based on accessible habitat area and the biological characteristic information of the returning adult salmon. Estimates of emigrating juvenile salmon (i.e., pre-smolt, smolt) using rotary screw traps, as well as mean parr densities by electrofishing on two tributaries of the Saint John River are assessed against reference levels.

Overall, the available data on salmon in DU 16 indicates that populations are persisting at low abundance levels. The One-Sea-Winter (1SW) and Multi-Sea-Winter (MSW) returns to counting facilities were the lowest on record in 2012, and, as a result, the wild smolt to 1SW and 2SW salmon return rates were both less than 0.4% on the Nashwaak River. In the past five years, estimated adult abundance on the Saint John River (SJR) upriver of Mactaquac and on the Nashwaak River has averaged about 7% (2-13%) and 22% (3-37%) of their respective conservation egg requirements. The estimated egg deposition upriver of Mactaquac has declined at rates in excess of 80% over the last 15 years, while Nashwaak egg deposition has also declined but to a lesser degree (27-50%) over the same time period depending on the model. Pre-smolt and smolt estimates contributing to the 2012 smolt class for the Tobique River were the highest since monitoring commenced in 2001, and the minimum smolt abundance estimate on the Nashwaak River was higher than 2011 but below the previous 5-year mean. These annual smolt production estimates for both rivers have been less than 0.6 smolts per 100 m^2 of productive habitat which is low in comparison to the reference value of 3.8 smolts per 100 m^2 (Symons 1979). Juvenile densities in the Tobique and Nashwaak rivers were considerably below reference values (Elson's norm) in 2012. Adult returns to other monitored rivers within the DU were extremely low, with decline rates in excess of 80% over the last 15 years for the Magaguadavic River. Decline rates were about 65% when considering total escapement of 1SW and MSW returning adults to DU 16 over the last 15 years. Electrofishing surveys at 189 sites within most of the rivers or tributaries within the DU revealed that juveniles are still present in most of the drainages but at low densities. The systems with the highest mean densities were all tributaries of the SJR, which included the Shikatehawk, Little Presquile, Keswick, Nashwaak, Canaan and Hammond systems.

The proposed recovery target for salmon of the OBoF DU has both an abundance and distribution component. The short-term distribution target was based on seven criteria designed to maintain genotypic, phenotypic, and geographic representation of the DU while offering the best opportunity for recovery. The short-term distribution target is to support the persistence of salmon in the seven priority rivers. Abundance targets are set using the conservation egg requirement of 2.4 eggs per m^2 of productive habitat. The short-term abundance target for the OBoF DU is to annually achieve the conservation egg requirement in all the seven priority rivers selected for distribution targets. Combined, short-term target rivers represent 56% of the salmon habitat in the OBoF region. This target translates to approximately 54.4 million eggs, which could be produced by 23,500 adult salmon within the 22.62 million m^2 of productive habitat area. The long-term abundance target is 97 million eggs in the currently accessible 40.46 million m^2 of productive habitat area. This egg deposition could be produced by 41,200 adult salmon.

Évaluation du potentiel de rétablissement de la population de saumon de l'Atlantique (*Salmo salar*) de l'extérieur de la baie de Fundy : État, tendances, répartition, caractéristiques du cycle vital et objectifs de rétablissement

RÉSUMÉ

Dans le cadre du processus d'évaluation du potentiel de rétablissement qui a été lancé par la désignation des saumons de l'Atlantique de l'extérieur de la baie de Fundy en tant qu'espèce en voie de disparition en 2010 par le Comité sur la situation des espèces en péril au Canada (COSEPAC), le présent document met à jour les données sur l'état, les tendances et le cycle biologique qui ont été publiées en dernier dans l'étude de Jones *et al.* (2010) aux fins d'examen par le COSEPAC (2010). De nouveaux renseignements sur l'aire de répartition, la répartition et les densités actuelles de salmonidés juvéniles sauvages à partir d'un vaste relevé de pêche à l'électricité effectué en 2009 et l'abondance et la répartition des objectifs de rétablissement pour l'unité désignable (UD) 16 y figurent également.

Les dénombrements de saumons adultes et les estimations des montaisons aux barrières de dénombrement (p. ex. passe migratoire, barrage de comptage) ainsi que les reproducteurs subséquents sont évalués par rapport aux exigences de ponte pour la conservation déterminées pour chaque rivière repère en fonction de la zone d'habitat productif accessible et des renseignements sur les caractéristiques biologiques des saumons adultes en montaison. Les estimations des saumons juvéniles qui émigrent (présaumoneaux, saumoneaux) sont évaluées par rapport aux niveaux de référence au moyen des pièges rotatifs et des densités moyennes de tacons obtenus par pêche à l'électricité dans deux affluents du fleuve Saint-Jean.

Dans l'ensemble, les données disponibles sur le saumon dans l'unité désignable 16 révèlent que l'abondance des populations reste basse. Les montaisons de saumons unibermarins et de saumons pluribermarins aux barrières de dénombrement étaient au niveau le plus faible jamais enregistré en 2012 et, par conséquent, le taux de montaison des saumoneaux sauvages unibermarins et pluribermarins était inférieur à 0,4 % pour la rivière Nashwaak. Au cours des cinq dernières années, les estimations de l'abondance des saumons adultes du fleuve Saint-Jean en amont de la rivière Mactaquac et dans la rivière Nashwaak étaient d'environ 7 % (de 2 % à 13 %) et 22 % (de 3 % à 37 %), par rapport aux exigences de ponte pour la conservation. On estime que la ponte en amont de la rivière Mactaquac a diminué à des taux de plus de 80 % au cours des 15 dernières années. La ponte dans la rivière Nashwaak a également diminué au cours de la même période, mais dans une moindre mesure (de 27 % à 50 %), selon le modèle. Les estimations de présaumoneaux et de saumoneaux contribuant à la classe d'âge 2012 dans la rivière Tobique étaient les plus élevées depuis le début de la surveillance, en 2001, et l'abondance minimale de saumoneaux estimée dans la rivière Nashwaak était plus élevée qu'en 2011, mais inférieure à la moyenne précédente sur cinq ans. Ces estimations de la production annuelle de saumoneaux pour ces deux rivières étaient de moins de 0,6 saumoneau par 100 m^2 d'habitat productif. Il s'agit d'un taux faible par rapport à la valeur de référence de 3,8 saumoneaux par 100 m^2 (Symons 1979). Les densités de juvéniles dans les rivières Tobique et Nashwaak étaient grandement inférieures aux valeurs de référence (norme d'Elson) en 2012. Le taux des montaisons des saumons adultes vers d'autres rivières surveillées au sein de l'unité désignable était extrêmement faible, se traduisant par un taux de déclin de plus de 80 % au cours des 15 dernières années pour la rivière Magaguadavic. Le taux de déclin était à environ 65 %, compte tenu du taux des échappées totales des saumons unibermarins et pluribermarins adultes retournant dans l'unité désignable 16 au cours des 15 dernières années. Des relevés de pêche à l'électricité à 189 emplacements situés dans la plupart des rivières et des affluents de l'unité désignable ont révélé que les juvéniles sont toujours présents dans la plupart des bassins versants, mais que leur densité est faible. Les réseaux avec les densités

moyennes les plus élevées étaient tous des affluents de la rivière Saint-Jean, notamment les rivières Shikatehawk, Little Presquile, Keswick, Nashwaak, Canaan et Hammond.

L'objectif de rétablissement proposé pour le saumon de l'unité désignable de l'extérieur de la baie de Fundy comprend à la fois des composantes d'abondance et de répartition. L'objectif de répartition à court terme était basé sur sept critères visant à maintenir le génotype, le phénotype et la représentation géographique de l'unité désignable tout en offrant la meilleure possibilité de rétablissement. L'objectif de répartition à court terme vise à appuyer la persistance du saumon dans les sept rivières prioritaires. Les objectifs d'abondance sont établis au moyen de la ponte requise pour la conservation, soit 2,4 œufs par mètre carré d'habitat productif. L'objectif d'abondance à court terme pour l'unité désignable de l'extérieur de la baie de Fundy est d'atteindre chaque année la ponte requise pour la conservation dans les sept rivières prioritaires sélectionnées pour les objectifs de répartition. Ensemble, les rivières visées par l'objectif à court terme représentent 56 % de l'habitat du saumon dans la région de l'extérieur de la baie de Fundy. Cet objectif se traduit par environ 54,4 millions d'œufs qui pourraient être produits par 23 500 saumons adultes dans les 22,62 millions de mètres carrés de la zone d'habitat productif. L'objectif d'abondance à long terme est de 97 millions d'œufs dans les 40,46 millions de mètres carrés d'habitat productif actuellement accessibles. Cette ponte pourrait provenir de 41 200 saumons adultes.

INTRODUCTION

The Outer Bay of Fundy [OBoF; Designatable Unit (DU) 16] Atlantic Salmon population was designated as 'endangered' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2010. Prior to the COSEWIC review, Fisheries and Oceans Canada (DFO) conducted an extensive review of their information related to all Atlantic Salmon populations in Canada, which developed into the Conservation Status Report (CSR) (DFO and MRNF 2008). This geographic area was labelled as Conservation Unit 17 (CU 17) in the CSR and Salmon Fishing Area 23 (outer portion) as a DFO management area (Jones et al. 2010). Designatable Unit 16 encompasses the 11 rivers within the Saint John River (SJR) Basin and the nine southwestern basins of New Brunswick (NB) discharging into the Bay of Fundy and Passamaquoddy Bay between the SJR Basin and the USA-Canada border (Marshall et al. 2014).

Atlantic Salmon are an anadromous species with a complex life history that involves residence in both freshwater and marine habitats over a life span of 4, 5, and 6 or more years. Adult OBoF salmon spawn in their natal rivers in October and November. Young develop until May or June in gravel nest pits, emerge as fry, and grow as parr feeding on invertebrate drift. Parr 'smoltify' mostly after 2 or 3 years in fresh water and enter the ocean as post-smolts, where they grow rapidly to maturity. Adults first return to spawn in their natal rivers after one, two and occasionally 3 winters at sea. Some survive after reproduction, return to sea the subsequent spring and return again to spawn in consecutive and/or alternating years.

Compared to their Inner Bay of Fundy (IBoF) counterparts, OBoF salmon differ by having a higher incidence of maturation as Two-Sea-Winter (2SW) fish, a lower incidence of females among 1SW fish and they conduct extensive migrations to the North Atlantic. They group separately from IBoF and most other populations at multiple allozyme loci and have, therefore, been considered a distinct regional grouping (DFO and MRNF 2008). A description of temporal and spatial habitat use for different life stages is provided in the OBoF salmon habitat considerations companion document (Marshall et al. 2014).

This document updates the status (adult, juvenile, and smolt) and trends (adult) information that was provided in Jones et al. (2010) for the COSEWIC (2010) review, as well as the recent life history characteristics. The document will also provide new information related to the current range, distribution and densities of wild origin juvenile salmon from an extensive electrofishing survey completed in 2009. Abundance and distribution recovery targets for DU 16 are also presented. Most of this information contributed to the development of a Recovery Potential Assessment (RPA) Science Advisory Report (SAR) for OBoF population or DU 16 (DFO 2014). This document addresses: status, trends, distribution, life history characteristics, and recovery targets (Terms of Reference [ToRs] 1, 2, 4 in Appendix 1). Along with the 'Habitat' considerations document (Marshall et al. 2014), other documents contributing information on the RPA for OBoF salmon (DFO 2014) are those addressing 'Threat' considerations (Clarke et al. 2014), 'Genetic' considerations (O'Reilly et al. 2014), and 'Population Viability Analysis' (Gibson et al., unpublished report[1]).

Population status of Atlantic Salmon in the Saint John River is assessed annually from data collected at the Mactaquac Dam, as well as from the Tobique and the Nashwaak rivers, the largest salmon-producing tributaries upstream and downstream, respectively, of Mactaquac

[1] Unpublished supporting document by A.J.F. Gibson, R.A. Jones, and G.J. MacAskill, on the "Recovery Potential Assessment for Outer Bay of Fundy Atlantic Salmon: Population Dynamics and Viability" (2014)."

Dam. Adult salmon counts and estimates of returns to counting facilities (i.e., at Mactaquac Dam and in the Nashwaak River) are evaluated against conservation egg requirements that were determined for each index river based on accessible habitat area and the biological characteristics of the returning adult salmon. Programs based on mark-recapture experiments to estimate smolt production take place on the Tobique and Nashwaak rivers. For the Tobique River, this includes an estimate of the fall pre-smolt migration the year before. Electrofishing surveys, from which the density of age-0, age-1, and age-2 and older juveniles are estimated and assessed against reference levels, take place on the Tobique and Nashwaak rivers. Outside of the Saint John River system, the only other assessment activities in DU 16 are counts of returning adult salmon to the fishway on the Magaguadavic River. The fishway on the St. Croix River has not been monitored since 2006.

The Maritime Provinces' commercial salmon fishery has been closed since 1984 and, after several buy-backs of licences, has only four eligible but inactive licences remaining in the Saint John River area. Due to the persistent failure of populations to achieve the conservation requirement, the Aboriginal food fisheries and the recreational fisheries have been closed on the Saint John River system since 1998 and similarly, the aboriginal food fishery and recreational fisheries have been closed since 1998 on the Magaguadavic and St. Croix rivers. However, there is some by-catch of salmon in net fisheries in the Saint John River estuary, as well as some illegal fishing taking place throughout the Saint John River system.

SAINT JOHN RIVER UPRIVER OF MACTAQUAC DAM

Physical attributes, salmon production area (updated *in* Marshall et al. 2014), barriers to migration, fish collection and distribution systems, the role of fish culture operations (updated *in* Jones et al. 2010; Clarke et al. 2014) and biology of the populations of the Saint John River drainage (Fig. 1), have been previously described in Marshall and Penney (1983). In 1983, the status of the salmon populations, since 1970, was evaluated (Penney and Marshall 1984) and continued through to 2008 (Jones et al. 2010). The assessment documents for the 1998 and 1999 returns were less detailed than those done previous to 1998 (Marshall et al. 1999a, 1999b, 2000). From 2000 to 2002, stock status was reported in the status overview documents for Atlantic Salmon in the Maritime Provinces (DFO 2001, 2002, and 2003). The approach used in this assessment is similar to that of the last detailed assessment (Jones et al. 2010).

RETURNS DESTINED FOR UPRIVER OF MACTAQUAC DAM

Methods

Adult salmon are captured and counted at the fish collection facilities at the Mactaquac Dam and at an adult trap operated in the migration channel at the Mactaquac Biodiversity Facility (MBF). In most years, both fish trapping facilities operate from early-May until late-October. In 2012, both of these collection facilities were operated from May 17 to October 25.

Salmon captured at the fish collection facilities were sorted at the MBF sorting facility and were classified as small or large and as either: wild origin, hatchery origin, captive-reared origin, aquaculture escape or landlocked salmon. For the most part, since the construction of the Mactaquac Dam, fish with an adipose fin but with some fin erosion were classified as hatchery origin if interpretation of scale patterns confirmed that they were not an aquaculture escape. From the late 1990s until recently, hatchery origin salmon that were released as 1-year smolts from the MBF or as juveniles (essentially fall parr) released upriver of Mactaquac, were principally identified by the absence of an adipose fin. Captive-reared origin salmon previously released as mature adults and returning to Mactaquac Dam as reconditioned adults were identified by a v-notch in their adipose fin. Suspected aquaculture escapes were identified by considerable erosion and partial regeneration of fin rays on all fins including the upper and/or

lower lobes of the caudal fin, the presence of an adipose fin and the interpretation of scale samples. Landlocked salmon were identified as being smaller in body size (shorter and slender) than a typical sea-run grilse and, in most cases, had fin erosion or clipped fins (adipose) while all other salmon were classified as wild origin, including returns from hatchery origin unfed and feeding fry, as well as progeny from captive-reared spawners (released primarily to the Tobique River since 2003). Both of these groups are indistinguishable from wild origin fish.

Marshall and Jones (1996) described the difficulty of distinguishing between adult returns from natural versus artificial recruitment because of the increasing numbers of unmarked hatchery distributions in the early and mid-1990s. From 1998 until 2010, the majority of the fall fingerling parr released upriver of Mactaquac Dam have had the adipose fin removed (Appendix 2; Appendix 3; Fig. 2a, b). To improve the capacity to distinguish hatchery origin fish, the adipose fin was also removed from the majority of the age-1 hatchery smolts released below Mactaquac Dam from 1998 until 2005 (Fig. 2c). In recent years, scale samples are taken from approximately every fourth hatchery and wild fish (exceptions include the complete sampling of all broodstock), but it was as high as every second fish in 2008 (Jones et al. 2010). The proportion of wild and hatchery origin in the count was adjusted based on interpretation of these scales. The procedures used to adjust counts are described in Marshall and Jones (1996) and have been consistently applied since 1995. The adjusted counts at Mactaquac Dam were used to estimate the returns and return rates for hatchery fish released as age-1 smolts and as age-0 parr. Multi-Sea-Winter (MSW) salmon include those fish that return following two or more winters at sea and repeat spawners.

Salmon by-catch in the lower river and in the Saint John Harbour from Shad and Gaspereau net fisheries was monitored by DFO fishery officers, but annual estimates of catch are unknown; therefore, to be consistent with previous assessments; the assumed catch rates were 1% of the One-Sea-Winter (1SW) and 2.5% of the MSW river returns (Marshall and Jones 1996). These catch rates are thought to exclude any losses due to illegal fishing (or poaching). Catches of salmon destined for upriver of Mactaquac Dam and caught downriver were assumed to consist of hatchery and wild origin salmon in the same proportions as the adjusted counts at Mactaquac. Therefore, estimated total returns of 1SW and MSW salmon (wild and hatchery origin) from upriver of Mactaquac Dam was the sum of the adjusted counts at Mactaquac Dam and the estimated removals in the main stem downriver of Mactaquac Dam (from illegal fishing and by-catch).

Results

Unadjusted counts of salmon at Mactaquac in 2012 totalled 84 1SW and 125 MSW salmon (Table 1). Three of the 84 1SW salmon counted at Mactaquac were reassigned to the MSW category on the basis of scale interpretation (Table 1). Interpretation of scales shifted the hatchery component to 33 1SW fish from 28 (Table 1) and to 59 MSW fish from 45. The adjusted counts proportioned by age composition among hatchery and wild components since 1992 are tabled in Appendix 4. There were no aquaculture escapes or repeat spawning captive-reared origin fish identified among the salmon returns in 2012 (Table 1).

DFO fisheries officers reported illegal fishing in the main stem downriver of Mactaquac Dam in 2012 but did not observe any salmon being removed from the river. Total removals in 2012 were estimated to be four MSW salmon from by-catch in the Shad and Gaspereau nets in the lower river and in the Saint John Harbour area (Table 1).

Adjusted wild origin and hatchery origin returns in 2012 were 81 1SW and 132 MSW fish (Table 1; Fig. 3). Adjusted returns of wild origin 1SW salmon decreased by 92% from those of 2011, and were the lowest annual estimate since 1970 (Table 3). Adjusted returns of wild origin MSW salmon decreased by 76%, and were also the lowest in 43 years (Table 3). The adjusted return rate to Mactaquac Dam of hatchery origin 1SW fish released as 1 year-old smolts was

0.017%, an 88% decrease from the previous year and the lowest value observed in the time series (Table 4a; Fig. 4). The return rate of the 2010 1 year-old smolt class as maiden hatchery origin 2SW salmon (Table 4b; Fig. 4) was 0.066%, the second lowest value on record. It is important to note that since 2006, with the exception of 2008, all hatchery origin smolts released were progeny of captive reared adults, collected as juveniles on the Tobique River, that were spawned at MBF. Any concern that smolts produced from captive-reared spawners might have a lower survival at sea than smolts produced from sea-run spawners can be alleviated as the 5-year mean smolt-to-1SW return rate for progeny of captive-reared broodstock (smolt classes 2006-2011; except 2008) was 0.498, which is very comparable to the 0.376 smolt-to-1SW return rate for progeny of sea-run broodstock (smolt classes 2001-05) (Table 4a).

REMOVALS OF FISH UPRIVER OF MACTAQUAC DAM

Methods

Removals from the potential spawning escapement destined for the traditional production areas upriver of Mactaquac Dam include:

a) salmon passed or trucked upriver of Tinker Dam on the Aroostook River (Fig. 1),

b) salmon retained at MBF as broodstock or mortalities from handling operations at Mactaquac,

c) salmon estimated to have been lost to illegal fishing (or poaching) upriver of the Dam (losses to illegal fishing include those estimated to have been taken in the net fishery on the Tobique River), and

d) known mortalities from fishways (i.e., Beechwood, Tobique and/or Tinker Dam) or the Tobique Half Mile Barrier.

If detailed information was not available for the losses, they were apportioned to hatchery/wild components on the basis of the composition of fish released upriver of Mactaquac.

Results

Reports from area fisheries officers indicated that there was less illegal fishing near Tobique Narrows Dam in 2012, but the total number of fish harvested was unknown. Less illegal fishing is supported by a reduction in the percentage salmon with net marks that are captured at the Tobique Narrows Fishway (Clarke et al. 2014). Using illegal harvest estimates determined by Jones et al. (2004), it was estimated that 5 1SW and 7 MSW salmon would have been removed by this illegal fishery. Since 2005, no adult salmon from Mactaquac have been transported to the Aroostook River upriver of Tinker Dam, although there were 6 1SW and 16 MSW fish counted at the Tinker Dam fishway (Table 5a, b). The area upriver of Tinker Dam was excluded from the "upriver of Mactaquac" conservation requirement (Marshall et al. 1997), so these 22 sea-run fish were not included in the escapement estimates. There were an additional 13 captive-reared salmon captured and released upriver of the Tinker Dam in 2012 (Table 5b).

Total river removals from all sources (upriver and downriver of Mactaquac Dam) were estimated at 11 1SW and 35 MSW fish (Table 5a) and, for the second consecutive year, no sea-run salmon were held at Mactaquac for broodstock.

CONSERVATION REQUIREMENTS

The conservation requirement for the Saint John River upriver of Mactaquac Dam is based on an accessible salmon-producing rearing area of 13,472,200 m^2 (Marshall et al. 1997) with stream gradients >0.12% (Amiro 1993). This rearing area excludes the Aroostook River, the hydro dam head ponds, and 21 million m^2 of river with gradient <0.12% (Marshall et al. 1997). Given the conservation egg deposition rate of 2.4 eggs/m^2 (Elson 1975; CAFSAC 1991), the

conservation requirement is 32,330,000 eggs. The numbers of spawners necessary to obtain the conservation requirement has been estimated to be 4,900 MSW and 4,900 1SW salmon (Marshall et al. 1997). Similar to previous years, egg deposition and the number of spawners in 2012 were estimated on the basis of length, external sexing and interpretation of age from scales collected from fish captured at the Mactaquac Dam fishway (Jones et al. 2010).

ESCAPEMENT

Sea-Run

Collation of the total sea-run (excluding captive-reared spawners) returns (Table 1) and total removals (Table 5a) of wild and hatchery fish, in 2012, indicates that escapement was 97 MSW salmon and 70 1SW salmon (Table 6).

Biological characteristics (female mean length, proportion female) from 1996 to 2012 have been summarized for 1SW and MSW salmon by origin (Table 7a, b). On average, female 1SW salmon are about 60 cm, carry about 3,700 eggs, and represent less than 10% of the total 1SW returns. However, female MSW salmon average about 77 cm, bearing about 7,000 eggs and represent about 90% of the MSW returns. Using the length-fecundity relationship calculated for Saint John River salmon (eggs = $430.19e^{0.03605X\text{fork length}}$; Marshall and Penney 1983), as well as the mean lengths and estimated escapement in 2012 upriver of Mactaquac Dam, the total estimated egg deposition was 0.54 million eggs (0.040 eggs per m^2), or 2% of the conservation requirement. This is an 87% decrease of the value estimated in 2011 and the lowest estimate in 43 years (Fig. 5). Estimated eggs from wild and hatchery 1SW fish comprised about 3% of the total deposition. Eggs from hatchery origin 1SW and MSW salmon potentially contributed 35% of the total deposition (Table 7b).

Captive-Reared

The MBF produces and releases salmon at various life stages to mitigate the effects of hydroelectric development on salmon in the SJR associated with the construction of Mactaquac Dam in the late 1960s. From the early 1970s to the mid-2000s, hatchery broodstock for the program has consisted of 200-300 wild sea-run adults each year (Clarke et al. 2014). Over the past decade, the program at the MBF has been re-focused with the objective of conserving and restoring a declining resource (Jones et al. 2004). Thus, discussion among DFO staff, the Saint John River Management Advisory Committee members, and the Saint John Basin Board members resulted in a program change in 2004. The current program replaces a large portion of the traditional smolt production with production of age-0 fall parr. Additionally, the program utilizes captive-reared adults, originally collected from the wild as juveniles, for both broodstock and adult releases for natural spawning upriver of the Mactaquac Dam. All releases are into tributaries of origin above Mactaquac Dam, mainly in the Tobique River.

In 2012, adult releases from the captive-reared broodstock program were distributed to sites in the Tobique River and at one site just downriver of the confluence with the main Saint John River near Perth-Andover. Using the mean length for each age category and a length-fecundity relationship (eggs = $337.93e^{0.0436X\text{fork length}}$; Jones et al. 2006) for captive-reared broodstock, the sexually mature females potentially produced another 5.49 million eggs (Table 7c), or an additional 14% of the conservation requirement (Fig. 5).

TRENDS IN RETURNS AND ESCAPEMENT

Methods

Trends in abundance were analyzed for the salmon population upriver of Mactaquac Dam from wild 1SW returns, hatchery 1SW returns, wild MSW returns, hatchery MSW returns, total wild-origin returns, total hatchery-origin returns, total 1SW returns, total MSW returns, combined

1SW and MSW returns, as well as total egg deposition from wild and hatchery-origin 1SW and MSW spawners (Table 3). Trends in these ten groups were analyzed over the most recent 15-year time period using two methods described by Gibson et al. (2006). These same methods were used to quantify trend in adult abundance and egg depositions up to 2008 (Jones et al. 2010) and were used to examine trends in adult abundance for Southern Uplands (Bowlby et al. 2013) and Eastern Cape Breton (Levy and Gibson 2014) populations as part of the RPA process.

The first approach was the commonly used "log-linear model":

$$N_t = N_0 e^{zt},$$

where N_0, the estimated population size at the start of the time series, and z, the instantaneous rate of change in abundance, are estimated parameters. For a given value of z, the percent change in the population size over a given number of years, t, is $(e^{Z^*t}-1)*100$. This model was fit using least squares after transformation of the data to a log scale.

The second approach was to calculate the extent of the decline as the ratio of the population size at the start (1997) and the end (2012) of the time period. In order to dampen the effect of year-to-year variability when using this approach, the 5-year mean population size (missing values were dropped during the smoothing) was used when calculating the ratio. The 5-year time period for smoothing was chosen to represent approximately one generation. In order to calculate confidence intervals, Gibson et al. (2006) parameterized the model into the form:

$$N_t = \begin{pmatrix} N_1 & s_t = 1 \\ N_1 p & s_t = 2 \end{pmatrix},$$

where s is a state variable that indicates whether a year is in the first or second time period. The average abundance during the first time period (N_1) and the change in abundance between the two time periods (p), are parameters to be estimated. This model, termed here the "ratio model" or the step function, estimates the extent of decline while not being influenced by data between the time periods of interest. Confidence intervals were estimated using likelihood ratios. A lognormal distribution was used for the error structure when fitting this model. Where a sufficient time series was available, both models were fit to 15-year time periods (the 15-year time period corresponds roughly to the three generation time period used by COSEWIC when evaluating conservation status).

Results

Plots of abundance and the log-linear fit for 1SW, MSW, and total returns all indicate considerable declines in population abundance over the past 15 years (Fig. 6), with predicted decline rates of 89.9%, 76.4%, and 86.1%, respectively (Table 8). The ratio model indicated a slightly lower rate of decline for 1SW returns (83.8%) and total returns (82.0%), but higher rates for MSW returns (81.9%; Table 8). The predicted decline rates for egg deposition were equally high, at 80.6% and 83.0% from the log-linear model and ratio method, respectively (Table 8; Fig. 6). The decline rate for wild MSW salmon is more severe than that of wild 1SW salmon, which is consistent with a greater loss of 2SW salmon from Northwest Atlantic populations (Chaput 2012). It is also important to consider that the wild 1SW (2008-12) and MSW (2009-12) returns have been influenced by progeny from the captive-reared releases of large salmon since 2004.

TOBIQUE RIVER – INDEX RIVER UPRIVER OF MACTAQUAC DAM

The Tobique River is located in northwestern NB, Canada (46° 46' N, 67° 42' W), and is 148 km long. The Tobique River is the largest salmon producing tributary of the Saint John River, upstream of the Mactaquac Dam. The salmon production area of the Tobique River has been estimated from orthophoto measurements (Amiro 1993) at 7.86 million m^2 (gradient >0.12) or 19.4% of the total salmon production area in DU 16 (Marshall et al. 2014; Table 9a). The Tobique Narrows Dam is located 1.5 km upriver of the confluence of the Tobique and Saint John rivers and has a pool and weir fishway for upstream migrants.

PARR DENSITIES

To evaluate status and trends of juvenile abundance upriver of Mactaquac Dam, electrofishing survey data conducted since 1970 on the Tobique River was used. The density calculations reported in Francis (1980) are adjusted from 12 of 15 sites to account for expanded sites and technique changes. Three of the 15 sites were no longer surveyed after mid 1980s due to significant changes in habitat. No electrofishing took place at any of these sites on the Tobique in 1980, 1987, 1990-91.

Methods

Density estimates (number of fish per 100 m^2 of habitat) from electrofishing surveys conducted at 12 sites in the Tobique River from 1970 to 2012 were determined using the following techniques:

- open sites (spot-checks only) using a previously established catchability coefficient of 34.7% (Jones et al. 2004),
- open sites (mark-recapture) using the adjusted Petersen method (Ricker 1975), and
- closed sites (barrier nets) using Zippen's (1956) maximum likelihood technique.

Numbers of parr by age were determined from stratified sampling of large parr in 0.5 cm length intervals. Generally one parr was scale sampled for each interval. For the mark-recapture sites, the number of fry (age-0 parr) per site was determined by applying the capture efficiency for age-1 and older parr to the number of fry captured during the marking pass.

The densities presented are for wild (or adipose fin present) parr only. Since 2004, wild parr could be progeny from either sea-run or captive-reared adults. For the most part, prior to 1998, all fall fingerling parr and unfed fry were released unmarked (Fig. 2a, b) and suspected hatchery origin parr captured during electrofishing surveys were determined by observations of fin erosion or condition made by field staff. From 1998 until 2010, most of the fall fingerling parr released have been adipose clipped (with exception of 2004 and 2008) and very few unfed fry (with exception of 2000) were released (Fig. 2a, b), making identification of wild parr more precise.

In conjunction with First Nation involvement in salmon assessment activities in 1992, there was a change in the electrofishing technique (from removal to mark/recap) and generally an increase in area sampled. In order to account for these changes and to evaluate the status and trends of juvenile salmon, the historical densities of fry and parr were re-adjusted using the same approach used by Marshall et al. (2000) and Jones et al. (2004) for the Nashwaak electrofishing data. For the Tobique River, most locations (sites 3, 5, 7, 9, 10, 13, 14, and 15) were surveyed twice within the same year, in multiple years; once using the old site old method and new site new method. The average and site specific adjustment factor are:

Average Adjustment Factors			
Site#	FRY	PARR	Years Surveyed
site#3	0.91	0.74	2 year
site#5	1.00	1.75	2 year
site#7	2.92	2.68	2 year
site#9	1.71	1.22	3 year
site#10	2.00	0.56	2 year
site#13	0.69	1.85	2 year
site#14	1.35	0.50	2 year
site#15	1.00	4.39	2 year
Mean	**1.45**	**1.71**	.

The average adjustment factor was used for the four sites (1, 2, 4, and 8) without site specific comparison data.

Sampling at each site has not taken place consistently each year (ranging from zero to 15) so, in an attempt to have a standardized time series, a generalized linear model (GLM) was used to predict the individual site density, the same approach used by Gibson et al. (2009). The GLM takes into consideration site and year for each age class of parr and was used in calculating the annual mean densities for each life stage.

Results

The mean density of wild fry at these 12 sites on the Tobique River, in 2012, was 4.9 fish per 100 m^2. This value is comparable to the mean density of fry observed in the 2000s (Table 10; Fig. 7). Since 1997, mean densities at these 12 sites have been well below the "Elson norm" of 29 fry per 100 m^2 (Elson 1967) and adjusted mean densities observed in the 1970s-80s (Fig. 7). Since 2005, the wild-origin fry numbers would also include progeny of the captive-reared spawners (2YR).

Mean density of age-1 and older wild parr at the 12 index sites was 6.7 parr per 100 m^2 in 2012 (Fig. 7). The mean density of age-1 and older wild parr in both 2011 and 2012 were slightly higher than the average density observed in the 2000s. These values are well below Elson's (1967) "normal index" of 38 small and large parr per 100 m^2 (Fig. 7) and in fact, only the 1979 adjusted mean value approaches the 'normal' index. The mean density of age-1 and older parr in the 1970s and 1980s was about 12 parr per 100 m^2 and decreased to about 8 parr per 100 m^2 in the 1990s (Fig. 7). Marshall et al. (2014) discusses:

> "The attainment of the 'norm' for parr, as a measure of suitability however, could be a lofty goal given the 'norms' weighting towards higher values for the Miramichi River[9]. The Miramichi sites outnumber Saint John River sites by a factor of about 2-3:1 and revealed densities for underyearlings, small parr and large parr that are 2.5, 6.3 and 1.3 times greater than those of the Tobique and Nashwaak rivers. The lower values for the Tobique River component in the 'norm' may well have been the result of habitat alteration in the 1950's, including the construction of the Tobique Narrows hydroelectric dam, controlled discharges for power generation from four storage reservoirs (Table 8) and indirect result of DDT spraying in 1953, and 1955-58 (Elson 1967)."

Despite the low densities, parr appear to be well distributed throughout the watershed as only one site was devoid of wild parr in 2012.

PRE-SMOLT AND SMOLT INVESTIGATIONS

In collaboration with the Tobique Salmon Protective Association, NB Wildlife Trust, and Atlantic Salmon Federation, fall pre-smolt and spring smolt investigations upriver of Mactaquac Dam have been conducted since 1998 and 2000, respectively. Several sampling techniques and assessment methods have been used and are described in Jones et al. (2004, 2006, 2010). The objectives continue to be:

1. to estimate the numbers of wild and hatchery pre-smolt and smolts emigrating from the Tobique River,
2. to obtain data on the fall and spring migration patterns of Tobique River pre-smolts and smolts, and
3. to collect juvenile salmon for the captive-reared program at the MBF that was initiated in 2001.

Parr that had a silvery appearance or faint-to-no parr marks were classified as pre-smolt. Fall telemetry studies have shown that some pre-smolts from the Tobique River migrate past Tobique Narrows Dam and overwinter in the main stem of the Saint John River (Carr 1999; Jones and Flanagan 2007).

Methods

Pre-smolt

Rotary screw traps (RSTs) have been consistently used to capture juvenile salmon at two different locations (Nictau and Three Brooks; Fig. 8) on the main stem of the Tobique River since 2001. Three were constructed by E.G. Solutions of Corvallis, Oregon, US (5-foot diameter), and the other by Key Mill Construction Ltd. of Ladysmith, BC, Canada (6-foot diameter), as described in detail in Chaput and Jones (2004). At the upper most site referred to as Nictau (Fig. 8), the Canadian constructed RST is generally operated from early October until mid/late November. The majority of the wild pre-smolts (and parr prior to 2010) were retained in a streamside rearing facility and later transported to MBF for the captive reared program (Table 11). For the most part, since 2004, all of the wild fry and hatchery parr were released unmarked. No juvenile salmon were marked and released for assessment purposes at this site.

At the lower site (Three Brooks; Fig. 8), two to four American constructed RSTs were situated in the main stem of the Tobique River just below the confluence of the Three Brooks tributary annually since 2001. They have been generally operated from late September until late November to early December (Table 12a). Identical to the Nictau site, all juvenile salmon were identified to stage, to origin and measured for fork length. Biological sampling included length, weight and scale sampling on a random portion of the catches as described in detail in Jones et al. (2010). From 2001 until 2005, all wild pre-smolts were retained for the captive reared program. Beginning 2006, an assessment component was added, so about two thirds of the wild pre-smolts were retained for the captive reared program and the remaining one-third of the wild origin and all hatchery origin pre-smolts were marked (streamer tagged, caudal punch) and then released in the main stem near Plaster Rock; approximately 3.5 km upriver of the RSTs (Fig. 8). These pre-smolts will be further referred to as "recycled" releases.

The wheels were generally fished once daily. Other species were counted and released at both capture locations. Hourly water temperature readings were recorded using a Vemco Ltd.© minilog installed in the main stem of the Tobique River at the Arthurette Bridge (Fig. 8). Environment Canada collected discharge data at a gauging station located in Riley Brook (Fig. 8). Discharge is affected by NB Power water storage facilities on four tributaries upriver of the Riley Brook gauging station.

Between 2002 and 2005, wild pre-smolt abundance was not assessed by mark-recapture techniques (Table 12a). Spring smolt estimates are available for the corresponding smolt

classes; 2003-2006 (Table 12b). Wild pre-smolt estimates are derived for these years using the approach of Gibson et al. (2009). This approach used the proportion of wild pre-smolts estimated in the fall of 2001 in relation to the number of wild smolts estimated the following spring (2002), except for the use of one additional year of data (pre-smolts [2006] and smolts [2007]). Combining the data for these two smolt classes, fall pre-smolts were 2.1 times more abundant or represented about two-thirds of the emigrating wild juveniles.

Smolt

One to four RTS(s) have been installed in the main stem of the Tobique River just downriver of the confluence of Three Brooks tributary (Fig. 8) in early May, generally after the spring ice run, until early June (Table 12b). The methods to identify the origin of the smolts and sampling protocols do not differ from those described in Jones et al. (2010) with exception that recycled smolts have been marked with a caudal punch rather than a streamer tag since 2011. One notable difference between the fall pre-smolt assessment and the spring smolt assessment is the periodic release of age-1 hatchery smolts (from MBF) upriver of the RSTs to estimate the capture efficiency of the wheels (Jones et al. 2004). Hourly water temperature readings and discharge data were recorded identical to the pre-smolt study. The intake gatewells at the Beechwood Power Generating Station have been periodically sampled for emigrating smolts usually during the latter part of the spring migration period. Smolts were captured, sampled and handled similar to the pre-smolt project.

Results

Pre-smolt – 2011

The four RSTs operated at the Three Brooks site captured a total of 2,098 pre-smolts (92% wild) and 191 parr (95% wild) during the six weeks of operation (Table 12a) in 2011. Of these catches, 1,406 wild pre-smolts were retained and transported to the MBF for the captive-reared program (Table 11). An additional 319 wild pre-smolts captured in the RST operated at Nictau by Tobique Protective Salmon Assoc. were also retained for the captive-reared program.

To estimate pre-smolt migration from the Tobique River, a total of 715 wild and hatchery pre-smolts were marked (caudal punch) and released up river at Plaster Rock. Of the 715 fish that were tagged and transported upstream approximately 3.5 km, 58 were recaptured, resulting in an efficiency of 8.0% and an estimated run of 26,325 fish (2.5 and 97.5 percentiles; 20,925 – 34,950), or 24,180 wild and 2,145 hatchery pre-smolts using the Bayesian estimation procedure (Table 12a). The 2011 wild pre-smolt estimate was about three times greater than the estimated number in 2010 and more than twice the previous 5-year mean (Table 12a; Fig. 9). The hatchery pre-smolt estimate in 2011 was 20% greater than the 2010 estimate and about 87% of the 5-year mean.

Smolt - 2012

In 2012, a total of 89 and 34 unmarked wild and hatchery smolts, respectively, were captured during the four weeks of operation at Three Brooks (Table 12b). The first smolt was captured on April 27 while 50% of the total catch had occurred by May 8 (Fig. 10).

Only 76 smolts were tagged with numerical streamer tags or marked with a punch in the caudal fin and then released at Plaster Rock. Four of the tagged smolts were recaptured in the RST at Three Brooks, resulting in an overall efficiency of 5.3%. The smolt run was not estimated using this data because of the small sample sizes.

A total of 1,949 age-1 hatchery smolts were released near Plaster Rock at the same location as the recycled smolts on 18 separate dates throughout the smolt migration period. Thirty-nine (2.0%) of these age-1 hatchery smolts from the MBF were recaptured at Three Brooks, typically one day after being released. This mark-recapture data generated a most probable Bayesian

estimate of 6,140 (2.5 and 97.5 percentiles; 4,940 – 8,400) or 4,400 wild and 1,700 hatchery smolts. The 2012 wild smolt estimate was 2.5 times greater than the estimate in 2011 and about 40% greater than the 5-year mean.

Biological Characteristics

The annual mean length of wild smolts (age classes combined) sampled during the spring RST operations has ranged from 14.1 (2002) to 15.5 (2010) cm since monitoring began in 2000 (Fig. 11). The mean length of wild smolts sampled on the Tobique River in 2012 was 15.2 cm, the second highest value since 2000 and 1.0 cm longer than the smolts sampled in 2011. Unlike the size data, age distribution has been relatively stable during the past seven years (Fig. 12). In 2012, the analysis of scale samples (n=30) collected from wild smolts in the Tobique River indicated that the majority (80.0%) were age-2 (Fig. 12). The remainder were age-3 smolts; no smolts were age-4 or older in 2012. Age-2 smolts have comprised more than 70% of the total wild smolt estimate in all but three years since 2001 (Fig. 12), although sample sizes have been less than 100 fish in eight of the twelve years.

NASHWAAK RIVER

With a drainage area of about 1,700 km^2, the Nashwaak River flows approximately 110 km in an easterly and southerly direction from Nashwaak Lake on the NB York/Carleton County line to its confluence with the Saint John River in Fredericton North (Figs. 1 and 15). It is the largest single salmon-producing tributary of the Saint John River downriver of Mactaquac Dam (Marshall et al. 2014). The amount of accessible productive (gradient >0.12%) habitat area on the Nashwaak River has been estimated from orthophoto measurements (Amiro 1993) at 5.69 million m^2 (Marshall et al. 1997) or 14.1% of the total productive habitat area within the OBoF region (Marshall et al. 2014). A salmon counting fence 23 km upriver from the confluence with the Saint John River (Fig. 13) was operated by DFO in 1972, 1973 and 1975 (unpublished[2]), and by DFO in cooperation with Aboriginal peoples from 1993-2012. In 2012, the fence was jointly operated by Kingsclear and Oromocto First Nations.

RETURNS

Methods

From June 1 until October 12, 2012, all sea-run Atlantic Salmon captured at the counting fence were counted, measured for fork length, categorized as either small or large salmon, classified as hatchery or wild on the basis of fin deformities and/or presence of adipose fin, and marked with a hole punch of the caudal (hatchery fish) or adipose (wild fish) fin. All visually suspected landlocked salmon captured at the fence were counted, measured for fork length, noted for fin clips and scale sampled to verify 'landlocked' designation. As in most years since 1993, all adipose clipped salmon (hatchery fish) and large wild salmon (>= 63 cm) were scale sampled along with every second small wild fish (<63 cm) to determine the age composition of the adult returns. Exceptions were made to the sampling routine when water temperatures at the fence exceeded 22°C. During these periods trap checks were made and fish were classified as 1SW or MSW salmon based on size, but no additional sampling occurred. In most years, holding pools upriver of the fence were seined in mid-September so that mark-recapture procedures (Gazey and Staley 1986) could be used to estimate the number of fish that may have bypassed the fence either before installation or when the fence could not operate properly due to high water. The combination of only a few fish marked at the fence and the high water experienced

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[2] Unpublished manuscript by A.A. Francis and P.A. Gallop, "Enumeration of adult Atlantic Salmon, *Salmo salar*, runs in 1972, 1973, and 1975 to the Nashwaak River, New Brunswick" (1979).

from late September and onwards were the reasons that no upriver pools were seined in 2012. Since no recapture data was available in 2012, the mean of the annual fence efficiencies was applied to the 1SW and MSW salmon fence count to estimate returns. The annual fence efficiencies for both 1SW and MSW salmon were calculated using the proportion of total estimate counted at the fence, for the 14 years in which count did not equal the total estimated returns.

Results

Raw counts at the Nashwaak River counting fence in 2012 were 20 1SW and 39 MSW salmon. The start and finish dates were similar to previous years, but because of extremely high water levels that topped the fence in late-June/early-July for about 6 days and then again in late-September and most of October, the fence counts are considered only a sub-sample of the total returns in 2012 (Table 13).

After scale analysis, 1SW salmon component were reduced to 16 1SW salmon as four small salmon were determined to be landlocked salmon (Table 2). No hatchery returns were among the final 1SW and MSW salmon unadjusted or adjusted counts. The low count and increased number of high water events when the trap was fishing poorly prevented any meaningful comparison of the run timing in 2012 to previous years, but the majority of 1SW and MSW salmon were counted during the month of July (Fig. 14a, b). Scale samples revealed that that the age composition of wild adults in 2012 was 32% 1SW fish, 49% virgin 2SW fish and 19% previous spawners. The proportion of 1SW and 2SW salmon returns was not similar to values observed in 16 of the last 20 years but closer to the exceptions which occurred in 1997, 2001, and 2009 (Fig. 15). The sea age breakdown of Nashwaak River wild salmon returns has been very similar to those wild salmon returning to Mactaquac Dam since 2000 (Fig. 15). Previous spawners represented 19% of the total returns in 2012, the high value in the time series is more related to the poor recruitment of maiden 1SW and 2SW salmon in 2012 than an increase in survival from first time spawners. The return rate of maiden 1SW and 2SW salmon to spawn a second time (estimated number returning to spawn second time / estimated number spawning as maiden) has been variable since 1993 but has been declining over time (Fig. 16), similar to the Lahave River population (Hubley and Gibson 2011), but unlike the increase observed for the Miramichi River population (Chaput and Benoît 2012). In contrast to the Miramichi population, Chaput and Jones (2006) found that there are no positive changes in life history characteristics (e.g., increased size at age or proportion female) of salmon upriver of Mactaquac Dam on the Saint John River, which could partially compensate for the reduced repeat spawner survivals in this population. Very few virgin 3SW salmon were observed in the Nashwaak population (Fig. 15).

The annual fence efficiencies were calculated for those years when the fence count did not equal the return estimate (Table 13). The mean fence efficiency for 1SW salmon was 0.56 and ranged from 0.37 to 0.84 yielded a return of 29 1SW salmon (19 – 43 fish). For MSW salmon the mean fence efficiency was 0.64 (ranging from 0.31 to 0.95) and when applied to the 39 fish counted gave a return of 61 MSW salmon (41 – 128) in 2012. Both the 1SW and MSW salmon estimates (all wild origin) were the lowest since the fence operation resumed in 1993 (Table 14).

Estimated 1SW returns decreased by 97% from those in 2011 and decreased by 96% compared to the 10-year mean (Fig. 17). MSW returns decreased by 89% from the 2011 returns and 71% from the 10-year mean. The return rate of the 2011 wild smolt class as 1SW salmon in 2012 was 0.33%, the lowest return rate since wild smolt assessments were initiated in 1998 (Table 15). The return rate of the 2010 wild smolt class as 2SW salmon in 2012 was 0.35%, the second lowest return rate observed and only 11% of the rate from the previous year (Table 15). The return rates determined from the 2012 wild 1SW and 2SW returns were extremely low but poor returns were observed on most rivers in eastern Canada that might indicate broad scale

factors affecting adult abundance in 2012. In fact, prior to 2012, the wild smolt to 1SW and 2SW returns on the Nashwaak show an increasing trend since smolt time series was initiated in 1998.

REMOVALS

As in previous years, no attempt has been made to estimate salmon by-catch in the Shad and Gaspereau net fisheries in the Saint John Harbour that may have been destined for the Nashwaak River. No 1SW or MSW salmon were removed from the fence trap for Nashwaak Watershed Association restoration initiatives. No salmon mortalities were observed during the counting fence operation in 2012. DFO fishery officers reported no illegal activities targeting salmon destined for or within the Nashwaak watershed. Therefore, no corrections were made for illegal removals.

CONSERVATION REQUIREMENTS

Salmon production area upriver of the counting fence is estimated to be 5.35 million m^2 (90% of the total river estimate) and the conservation requirement is 12.8 million eggs (Marshall et al. 1997). The numbers of spawners necessary to obtain the conservation requirement upriver of the counting fence are estimated to be 2,040 MSW and 2,040 1SW salmon (Marshall et al. 1997). As in previous assessments, egg deposition and the number of spawners in 2012 were estimated on the basis of length, external sexing and interpretation of age from scales collected from fish passing through the fence.

ESCAPEMENT

Total escapement upriver of the fence was estimated to be 29 1SW and 61 MSW salmon (Table 14). Proportion female and mean length for wild 1SW and MSW spawners upriver of the fence for the years of operation are summarized by Gibson et al. (unpublished report[3]). Using the biological data collected on the few fish in 2012, the egg deposition was estimated to be about 322,000 eggs (0.07 eggs/m^2 or 3% of the egg requirement), the lowest estimate in the time series (Table 14). One-sea-winter females contributed 13% of the total estimated egg deposition.

TRENDS IN RETURNS AND ESCAPEMENT

Trends in returns and escapement to the Nashwaak River were analysed using the ratio method and the log-linear model described for the salmon population upriver of Mactaquac. These four data sets were analysed for the Nashwaak River:

1. 1SW returns,
2. MSW returns
3. combined 1SW and MSW returns, and
4. combined eggs deposited from 1SW and MSW spawners (Table 14).

Plots of abundance and the log-linear fit for 1SW, MSW, combined returns, and total egg deposition, all suggest declines in population abundance over the past 15 years (Fig. 18). Predicted decline rates from the log-linear model over the past 15 years for 1SW returns was 44.9% about 2.3 times higher than that predicted for MSW returns (18.8%) (Table 8). The log-linear model predicted similar decline rates (26.7%, 26.9%) for total returns and escapement

[3] Unpublished supporting document by A.J.F. Gibson, R.A. Jones, and G.J. MacAskill, on the "Recovery Potential Assessment for Outer Bay of Fundy Atlantic Salmon: Population Dynamics and Viability" (2014)."

over the same time period. However, the confidence intervals on these fits include negative values, indicating that it is possible that there was no change or even an increase in abundance in the past 15 years. This is likely a result of the high variability in the recent returns. The predicted decline rates using ratio model predicts similar decline rates (between 41 to 50%) for all four datasets analysed also with negative confidence intervals (Table 8; Fig. 18).

PARR DENSITIES

To evaluate status and trends of juvenile abundance on the Nashwaak, electrofishing survey data from 1970 until 2012 was used. Similar to the Tobique, the density calculations reported in Francis (1980) for seven of ten sites were adjusted to account for expanded sites and technique changes. Three of the ten sites were not included in the analysis because of significant changes in habitat or less frequently surveyed. No electrofishing took place at any of these sites in 1980.

Methods

Density estimates (number of fish per 100 m^2 of habitat) from electrofishing surveys conducted at seven sites (Fig. 13) from 1970 to 2012 were determined using the following techniques:

- open sites (spot-checks only) using a previously established catchability coefficient of 34.7% (Jones et al. 2004),
- open sites (mark-recapture) using the adjusted Petersen method (Ricker 1975), and
- closed sites (barrier nets) using Zippen's (1956) maximum likelihood technique.

As in the Tobique River, numbers of parr by age were determined from stratified sampling of large parr in 0.5 cm length intervals. Generally one parr was scale sampled for each interval. For the mark-recapture sites, the number of age-0 parr or fry for the site was determined by applying the capture efficiency for age-1 and older parr to the number of fry captured during the marking pass. Similar to recent years, a mean probability of capture was applied to sites done in 2008 in which zero parr were marked or recaptured or if only the marking pass was completed (Jones et al. 2004).

The densities presented are for wild (or adipose fin present) parr only. For the most part, prior to 1998, all fall fingerling and unfed fry were released unmarked and suspected hatchery origin parr captured during electrofishing surveys were determined through observations made by field staff of fin erosion or condition (Appendix 5). Between 1999 and 2006, most fall fingerlings released were adipose clipped and there were fewer unfed fry releases, thereby making the identification of wild parr easier and more accurate. Between 2008 and 2010, unclipped hatchery origin parr were determined by field staff based on fin erosion or condition. There have been no hatchery releases since 2010.

In conjunction with First Nation involvement in assessment salmon assessment activities in 1990-91, there was a change in the electrofishing technique (from removal to mark/recap) and generally an increase in area sampled. In order to account for these changes and to evaluate the status and trends of juvenile salmon the historical densities of fry and parr were re-adjusted using the same approach used by Marshall et al. (2000) and Jones et al. (2004). All seven sites were surveyed within the same year, for multiple years; once using the old site old method and new site new method. The site specific adjustment factors are:

	Average Adjustment Factors		
Site#	FRY	PARR	Years Surveyed
site#1	1.82	0.98	2 year
site#2	4.53	1.18	3 year
site#3	0.90	1.53	2 year
site#5	0.37	0.43	2 year
site#8	1.75	0.90	2 year
site#9	1.51	3.61	3 year
site#10	2.75	0.96	2 year
Mean	**1.95**	**1.37**	

Sampling at each site has not taken place consistently each year (ranging from zero to seven), so in an attempt to have a standardized time series, the same approach as taken by Gibson et al. (2009) was used, and a generalized linear model (GLM) was used to predict the individual site density. The GLM takes into consideration site and year for each age class of parr and was used in calculating the annual mean densities for each life stage.

Results

Mean density of wild fry at the seven historical sites in 2012 (one downriver and six upriver of the counting fence) was 12.9 fry per 100 m^2, a 10 fold increase from 2011 and above the mean density for 2000s (Table 16, Fig. 19). Since 1993, mean densities at the seven sites have been below the “Elson norm”, and ranging between 1.8 (2011) and 17.6 (2002) fry per 100 m^2. Mean annual densities from the 1970s and 1980s were 46.6 and 44.9 fry per 100 m^2.

Mean density of age-1 and older wild parr at the seven sites in 2012 was 4.0 fish per 100 m^2, similar to the previous year and slightly below the mean density observed for 2000s (Table 16; Fig. 19). Despite mean fry densities in the 1970s and 1980s that exceeded Elson's (1967) “normal index”, this failed to translate into mean parr densities that exceeded or even approached the ‘normal index’ of 38 small and large parr per 100 m^2 during the same time period (Fig. 19). Mean densities of age-1 and older wild parr in the 1970s and 1980s were 15.7 and 11.4 fish per 100 m^2.

SMOLT ASSESSMENT

A collaborative project between DFO and the Nashwaak Watershed Association Inc. (NWAI) to estimate the wild smolt production of the Nashwaak River has been ongoing since 1998. The smolt production estimates are valuable in examining recent trends in salmon populations for the following reasons:

1. they contribute to the development of current expectations for and limitations to salmon production on the Nashwaak River and probably other tributaries of the Saint John River downriver of Mactaquac Dam,
2. they provide a marine survival estimate examined through smolt-to-adult return rates where adult returns are derived from data collected at the Nashwaak River counting fence, and
3. they provide a basis for evaluating freshwater production which can be examined through parr-to-smolt and egg-to-smolt survival rates when estimates of juvenile densities of salmon and eggs deposition are available.

Methods

One or two American constructed RSTs have been installed and operated from mid-April/early-May until early-June in the main stem of the Nashwaak River just downriver of Durham Bridge on an annual basis since 1998. Generally, the RSTs were checked once daily during the peak migration and less frequently (every other day) as the daily catches decreased. All unmarked smolts were identified for origin (wild or hatchery). Up to a maximum of 100 wild smolts were

marked (either with numbered streamer tags or caudal punch) and released upriver near the confluence of the Tay River (since 2003) or Nashwaak Bridge (2002 and 2003) (Fig. 13). From 1998 until 2001, smolts were marked and released at a portable counting fence operated on the Tay River. A random sample of these smolts (maximum of 25) from the RST(s) was measured for fork length, weighed, and scale sampled on a daily basis. Marking and detailed sampling occurred on all hatchery origin smolts.

Hourly water temperature readings were recorded using a minilog thermometer installed in the main stem of the Nashwaak River at the adult counting fence location (500 meters downriver of the RST). Environment Canada collected discharge data at a gauging station located near Durham Bridge.

Results

In 2012, a total of 754 untagged wild smolts (a portion may have been from unclipped unfed fry distributed in 2010; Appendix 5) were captured during RST operations. In 2012, the mild spring which lead to warmer than normal water temperatures initiated the smolt migration earlier than anticipated (Fig. 20). In 13 of the 14 years of monitoring, at least 50% of the cumulative smolt catch had occurred after May 4 (Fig. 20). In 2012, 50% of the cumulative smolt catch had occurred on April 22. In fact, this date (50%) may have actually been earlier, as on the day of installation, April 17, morning water temperatures were recorded to be 9°C and April 18 catch was the second highest of the season. Smolt captures on the Tobique also indicated that the majority of the smolts migrated early in 2012 (Fig. 10) but not the earliest in the time-series, as observed on the Nashwaak (Fig. 20). Ideally smolt monitoring at both locations would occur for the exact same time period to allow for direct comparisons but in some instances this is not possible as ice or high water can delay the Tobique installation. This was the situation in 2012, as the Tobique RSTs were not operational until April 26 almost 10 days after the Nashwaak RSTs were in operation.

For the mark-recapture experiment, 715 wild smolts were marked with a caudal punch and released upriver of the RST at the mouth of the Tay River (Fig. 13). Of these, 60 (8.4%) were recaptured at the RST. This mark-recapture data generated a most probable Bayesian estimate of 8,975 wild smolts (2.5 and 97.5 percentiles; 7,250-11,800) emigrating from the Nashwaak River in 2012. High water prevented operation of the RSTs for approximately 72 hours from April 23 until April 26. Two significantly different efficiencies were noted (pre and post high water period) so the mark and recapture data were separated into two time periods. The most probable Bayesian estimate for each period added together resulted in preferred estimate of 11,060 wild smolts emigrating from the Nashwaak River in 2012 (Table 15). This represents an increase of 26% from 2011, which was 84% of the 5-year mean, and was the sixth lowest estimated total since smolt assessments commenced in 1998 (Table 15, Fig. 21). It should be considered a minimum estimate given the second highest catch of the season occurred on the first day of operation and the fact that the RSTs were not operated for 72 hours during what could be considered the peak part of the run.

Biological Characteristics

Since smolt monitoring was initiated, the annual mean fork length of wild smolts emigrating from the Nashwaak has ranged from 14.5 cm (2011) to 15.6 cm (2010) with a mean of 15.0 cm (Fig. 11). The fork length of all the wild smolts sampled in 2012 was 15.4 cm (n=154), which is the second largest mean length recorded in the time-series (Fig. 11). O'Connell et al. (2006) compared the annual mean fork length values of ten Atlantic Salmon populations in Eastern Canada, only two Newfoundland populations (Western Arm Brook and Campbellton) were consistency larger than the Nashwaak. Wild smolts have been predominately age-2 with the remainder being age-3 since monitoring began (Fig. 22). In 2012, age-3 smolts represented

39.6%, which was above average, of total juvenile emigrants and would help explain for the second largest mean length observed since 1998.

EGG TO SMOLT SURVIVAL

Egg to smolt survival on the Nashwaak River has been monitored since the spawning class of 1995. This has been possible with the annual wild smolt estimates (and corresponding age data) which began 1998. With one exception (the year class of 2003), egg to smolt survival has fluctuated between 0.3 and 1.0% (Fig. 23a, 23b) which is low relative to values observed on other rivers in Atlantic Canada (O'Connell et al. 2006). Jones et al. (2010) postulated that since mean fry (2004) and parr (2005) densities (Fig. 19) from that particular year class were not substantially higher than the previous years, they felt that increased survival was the result of a mild winter in 2005. Similar observations were observed on the Tobique River, with a higher than anticipated smolt estimate in 2006 on the Tobique River; the highest wild smolt estimate in the recent time-series (Fig. 9) could not solely be explained by mean parr density estimate in 2005 (Fig. 7).

MAGAGUADAVIC RIVER

Originating in Magaguadavic Lake, the Magaguadavic River flows South-easterly for 97 km to the Passamaquoddy Bay, Bay of Fundy, at St. George, NB (Fig. 24; Martin 1984). The 13.4 m-high dam and 3.7 Megawatt hydroelectric station (with four Francis turbines) located at the head-of-tide was replaced with a new 15 Megawatt hydroelectric station (with two Kaplan turbines) in 2004 (Jones et al. 2006). Upstream passage is provided by a fishway. A new downstream bypass and assessment facility was constructed in the new hydroelectric station. Assessment of the anadromous fish using the fishway is done with a trap in the third pool from the top of the fishway. In 2012, the fishway trap was monitored for salmon from May 1 until December 20 except for the month of June and the first few days of July when the trap was lifted during the alewife migration period. Salmon count data and analyses were provided by Atlantic Salmon Federation (Jon Carr, pers. comm.). In 2012, similar to the previous year, no fish of aquaculture origin captured at the trap were released back into the river. All salmon of suspected aquaculture origin were sacrificed for sampling of pathogens.

Wild returning salmon have been rapidly declining since 1992 and have averaged less than ten fish per year in the last ten years. A salmon conservation program coordinated by the Magaguadavic River Salmon Recovery Group and the Atlantic Salmon Federation, that involves a partnership with the aquaculture industry (Cooke Aquaculture Inc.), has been supplementing the wild population with hatchery releases since 2002 (Appendix 6). Aquaculture fish are suspected escapes from aquaculture cages in the Fundy Isle area which, in 2011, produced approximately 20,000 tonnes (NB harvest) of Atlantic Salmon which would be equivalent to about 4.7 million fish (Clarke et al. 2014).

RETURNS

There was one wild and no hatchery MSW salmon counted in 2012 (Table 2). Counts of 1SW salmon in the trap numbered 18 aquaculture escapes and one re-conditioned captive-reared broodstock in 2012. There were no wild or hatchery 1SW salmon in 2012 (Table 2). It is possible that some of the "wild" salmon counted may have been the result of early life stage juvenile escapes from any of the three private hatcheries in the drainage. Counts made since 1992, when aquaculture escapes were identified, and those in 1983-1985 and 1988, when escapes were largely unnoticed, are in Table 2. Wild-origin sea-run salmon were distinguished from aquaculture escapees by using external morphology and scale circuli characteristics. The anticipated return of 1SW salmon (age-2 smolt) from the release of almost 140,000 unfed fry in

2009 was not observed in 2012. Suspected aquaculture escapes continue to be captured in the fishway on an annual basis but were well below the 5- and 10-year means but were similar to the previous two years (Table 2).

REMOVALS

All aquaculture fish were sacrificed for disease testing. No fish tested positive for the ISA virus. No fish were removed for broodstock and there were no reported illegal removals. There has been no commercial fishery since 1983, and the Aboriginal food fishery and the recreational fishery have been closed since 1998.

CONSERVATION REQUIREMENTS

The conservation requirement of 1.35 million eggs is based on an estimated 563,000 m^2 of juvenile rearing habitat (Anon 1978a) and a conservation deposition rate of 2.4 eggs per 100 m^2 (Elson 1975; CAFSAC 1991). The numbers of spawners necessary to obtain the conservation requirement are estimated at 230 MSW and 140 1SW salmon (Marshall and Cameron 1995).

ESCAPEMENT

The one wild MSW salmon was released upriver of the fishway. Using the mean length-fecundity relationship for Saint John River salmon (eggs = $430.19e^{0.03605X\text{fork length}}$; Marshall and Penney 1983) and the estimated potential egg deposition from the one female was 7,160 eggs, less than 1% of the requirement. Estimates of escapement from wild and hatchery sea-run returns have been less than 5% from 1998 – 2005 (Jones et al. 2006) with no increases observed since 2006 (Table 2). Unlike 2011, there were no captive-reared adults released in 2012 by the Atlantic Salmon Federation staff to augment the potential eggs from the one sea-run return.

TRENDS IN RETURNS

Decline rates for the Magaguadavic River salmon population have been updated since those presented in Jones et al. (2010) to include the recent four years of counts. The rates were calculated using combined wild and hatchery 1SW and MSW returns (Table 2) with the log-linear model and ratio method described above. Plots of abundance and the log-linear fit for all returns predict considerable declines (80.2%) in population abundance over the past 15 years (Table 8; Fig. 25). The ratio method predicts an even higher rate of decline (91.6%).

ST. CROIX RIVER

The St. Croix River, a USA/Canada international river bordering the State of Maine and Province of New Brunswick, drains southeasterly into Passamaquoddy Bay in the Bay of Fundy. Approximately 1,619 km^2 of the drainage basin is in NB and 2,616 km^2 is in Maine (Fig. 26). Historically a significant producer of Atlantic salmon, this salmon population has succumbed to industrial development; initially cotton mills, then pulp mills, and now dams and headponds at three hydroelectric facilities. The main stem and East Branch (84 km), the Chiputneticook lakes (66 km) and Monument Brook (19 km) determine 169 km of the international boundary (Anon 1988), the fluvial portions of which comprise the bulk of the potential rearing area for Atlantic Salmon.

From 1997 to 2006, no naturally returning adult salmon has been released upriver. Returns in the late 1990s and 2000s have been mostly dependent on hatchery programs. Without a dramatic shift in survival at sea, these conservation efforts are not expected to yield any significant number of naturalized salmon in the near future. Hatchery releases since 1981 are

tabled in Appendix 7. No broodstock have been collected and no hatchery fish have been released since 2006. Any future returns would be dependent on natural production in the river, either from the progeny of hatchery releases or wild strays from other rivers.

RETURNS

The Milltown fishway near head-of-tide on the St. Croix River has been previously monitored by the St. Croix International Waterway Commission (Lee Sockasky, pers. comm.) until 2006, although no monitoring for returning adult salmon has occurred from 2007 to 2012. There were no wild returning adult salmon to Milltown fishway between 2000 and 2006 with the exception of one 1SW salmon in 2004 (Table 2). Since fishway monitoring has not taken place since 2006, the number of wild and hatchery 1SW and MSW returns is not available, but is expected to be extremely low.

CONSERVATION REQUIREMENTS

The conservation requirement of 7,389,000 eggs on the St. Croix River is based on an area of 3.079 million m^2 of juvenile production habitat (Anon 1988) and a conservation egg deposition rate of 2.4 eggs 100 m^2 (Elson 1975; CAFSAC 1991). The adult salmon requirements have been calculated on the basis of MSW salmon only. Using a male to female ratio of 1:1 and an average female fecundity of 7,200 eggs, the adult requirements for the Magaguadavic River are 2,052 MSW salmon. A re-evaluation of adult requirements in 1993 acknowledged the potential contribution to egg deposition by 1SW females and suggested 1,710 MSW and 680 1SW fish could potentially produce the egg requirement (Marshall and Cameron 1995).

TRENDS IN RETURNS

The latest decline rates for the St. Croix River salmon population were calculated by Jones et al. (2010) using combined wild and hatchery 1SW and MSW returns (Table 2) over the latest 15-year time period (ending in 2006) using the log-linear model and ratio method (Fig. 27). With no recent count data (since 2006) the plots of abundance and the log-linear fit for all returns has not been updated. The ratio model indicated a high rate of decline (96.1%) between two time periods ending in 1991 and 2006 and predicted decline in abundance over the same 15 year period was 97.1% (Jones et al. 2010).

DESIGNATABLE UNIT 16

PARR DENSITIES AND DISTRIBUTION

The total amount of drainage area, wetted habitat as well as the amount of productive habitat for the OBoF population or DU 16 is summarized in Table 9a. The habitat estimates for the Saint John River system have been updated from those documented in Marshall et al. (1997) and are identical to those reported in Marshall et al. (2014). These estimates are for the amount of accessible habitat based on digital spatial data from the NB Department of Natural Resources, air photos and orthophotographic maps. Areas with a gradient less than 0.12% are considered unproductive (Amiro 1993). The habitat estimates for the "outer Fundy complex rivers" are not as detailed and includes all wetted area independent of gradient (Table 9a).

An extensive electrofishing survey was conducted in 2009 by DFO, Department of National Defence, First Nations (Woodstock, Oromocto, Tobique), and conservation groups (Tobique, Hammond, Canaan, and ASF) to assess the presence/absence (area of occupancy) and relative density (fish per 100 m^2) of juvenile salmon in the rivers containing the accessible habitat in the DU. These collective efforts enabled 189 sites to be electrofished that was equivalent to more than 137,000 m^2 of habitat in most of the major rivers containing productive

salmon habitat within the DU (Table 9b; Fig. 28). The methods varied depending on the group leading the electrofishing surveys but in all cases a density of juvenile salmon (fry and parr) was determined. The majority of the sites were competed by DFO with assistance from First Nation technicians. The sites completed by DFO were open (no barrier nets) sites and densities of fry and parr were determined using a previously established catchability coefficient of 34.7% (Jones et al. 2004).

The mean density of wild fry at 72 sites (Fig. 28) within 20 tributaries upriver of the Mactaquac Dam in 2009 was 2.8 fish per 100 m^2 (Table 9b). This value is equivalent to about 10% of 'Elson norm' of 29 fry per 100 m^2 (Elson 1967). The mean density of wild parr (age-1 and older) for the sites upriver of Mactaquac Dam was 0.8 fish per 100 m^2 (Table 9b) a value equivalent to only 3% of the "Elson norm" of 38 parr per 100 m^2 (Elson 1967). The highest mean densities of juvenile salmon were observed on the Shikatehawk (25.3), Monquart (14.2) and on the Little Presque Isle (11.1) tributaries (Fig. 29). Wild juvenile salmon (combined age classes) were captured at 50 (69%) of the 72 electrofishing sites surveyed (Fig. 28).

The mean density of wild fry at the 93 sites (Fig. 28) downriver of Mactaquac Dam in 2009 was 1.8 fish per 100 m^2, or 6.2% of "Elson's norm" (Table 9b). The mean density of wild parr for the same sites located in tributaries below Mactaquac Dam was 1.9 fish per 100 m^2 or 5% of the "Elson norm". Largest mean densities of juvenile salmon were found within the Keswick (17.8), Canaan (11.0), Nashwaak (8.9) and Hammond (8.0) tributaries (Fig. 29). Wild fry or parr were captured at 60 (64.5%) of the 93 electrofishing sites completed (Fig. 28).

The mean density of wild fry for 24 sites surveyed within six rivers of the outer Fundy complex was 1.3 fish per 100 m^2 which is about 5% of "Elson's norm". The mean density of wild parr was 0.7 fish per 100 m^2, 2% of the "Elson norm" for parr. No wild juvenile salmon were captured at 16 of 24 sites surveyed (Fig. 28). All the juvenile salmon captured at the sites on the Magaguadavic River were believed to be either hatchery origin (i.e., unfed fry release in 2008 or 2009) or escapes from one of the freshwater aquaculture facilities (footnote Table 9b). It is also possible that a small portion of juveniles could have been progeny of the eight wild 1SW returns between 2007 and 2008 (Table 2).

TOTAL RETURNS

Jones et al. (2010) estimated the total 1SW and MSW returns to the Saint John River from 1993 to 2008 using the estimated returns to the Nashwaak River (upriver of the counting fence, Table 14) multiplied by the amount of habitat assessed (Total Nashwaak divided by Total SJR below Mactaquac= 0.2565), added to the estimated total returns for SJR above Mactaquac Dam (Table 3). The 1SW and MSW returns to other OBoF rivers were determined using the total returns to both the Magaguadavic and St. Croix rivers (Table 2), divided by the proportion of the habitat area assessed on the St. Croix and Magaguadavic (0.7082) in relation to total amount of habitat for the outer Fundy complex of rivers and added to the estimated Saint John River returns, which provided the total estimated 1SW and MSW returns to the DU. The same calculations were completed to provide updated totals for 1SW and MSW returns to the DU from 1993 to 2012. For consistency purposes, the habitat production estimates from Marshall et al. (1997) were used. If the updated habitat estimates reported by Marshall et al. (2014) were used, this would slightly increase (1-3%) the total return estimates but would not affect the decline rates.

Total estimated 1SW returns to the entire DU 16 in 2012 was 194 fish (Table 17). The estimated 1SW returns in 2012 were only 4% of both those estimated in 2011 and the previous 5-year means. The total estimated MSW returns to DU 16 was 371 fish, only 13% of the 2011 estimate (which was the highest estimate since 2001) and only 24% and 28%, respectively, of the 5- and

10-year means (Table 17). Total estimated returns (1SW and MSW combined) were only 565 fish the lowest in the time series and most certainly within the last century.

TRENDS IN RETURNS

Similar to the three index populations in DU 16 (i.e., SJR upriver of Mactaquac, Nashwaak [SJR downriver of Mactaquac], Magaguadavic [outer Fundy complex]) trends in: 1) 1SW returns, 2) MSW returns, and 3) combined 1SW and MSW returns (Table 17) were analysed for the entire DU over the last 15 years with the log-linear and ratio models. Plots of abundance and the log-linear fit for the groups indicate considerable declines in population abundance over the past 15 years (Fig. 30). The decline rates from the log-linear model for 1SW, MSW and combined returns were 73.2%, 52.1% and 63.5%, respectively (Table 8). In comparison to the decline rates reported by Jones et al. (2010), the 1SW increased from 62.2%, MSW decreased from 86.8% and combined decreased from 71.5%. The ratio model indicated very similar rates of decline for all three groups (68.3%, 68.3%, and 64.8%) when the earliest five years and the last five years of data were compared (Table 8).

RECOVERY TARGETS

The proposed recovery target for OBoF DU salmon has both an abundance and distribution component.

Distribution Target

On defining distribution targets for Southern Upland salmon in Nova Scotia, Bowlby et al. (2013) mention:

> "The initial steps in protecting biological diversity involve first identifying diversity, and then defining the units of diversity that require preservation (Wood 2001). Therefore, setting appropriate distribution targets for the recovery of Southern Upland Atlantic Salmon populations partially relies on knowledge of the diversity among populations in the DU. Environmental variation both within and among river systems, coupled with the natural homing ability of Atlantic Salmon, act in concert to promote and maintain the variability in life history characteristics found among Atlantic Salmon populations in the Southern Upland. Such local adaptation (and consequently biological diversity) would be expected to be the largest among the most dissimilar watersheds, provided that gene flow was relatively restricted among them."

Defining criteria for appropriate OBoF population distribution to support recovery is likely to be overly simplistic considering the known and unknown gaps in knowledge explaining current population status and trends. As any population, OBoF salmon have unique population (DFO and MRNF 2008), habitat (Marshall et al. 2014) and threat (Clarke et al. 2014) characteristics. Evidence has been presented demonstrating relatively little genetic variation within OBoF populations and more between OBoF and other larger populations such as Newfoundland and the Gulf of St. Lawrence (Verspoor et al. 2005). A likely exception to this view is the Serpentine Salmon that was thought to originate from the Serpentine River which flows into the Tobique system (Saunders 1978; Clarke et al. 2014).

The distribution target should encompass the range of genetic and phenotypic variability among populations and environmental variability among rivers. It should include rivers distributed throughout the DU to allow for gene flow among the rivers/populations. There is the expectation that including a wide variety of populations in the distribution target will enhance persistence, as well as facilitate recovery in the longer term.

Short-Term

Following applicable guidelines in DFO (2005) and based on material contained in this and other supporting companion research documents for the OBoF DU, the short-term distribution targets were based on seven criteria designed to maintain genotypic, phenotypic, and geographic representation of the DU while offering the best opportunity for recovery. Priority rivers were selected by assessing each OBoF river against criteria 1-6 (below) and assigning a weighted score (higher weights for more important criteria). Following the scoring exercise, rivers were listed by priority and representative geographic variation (criterion 7), was applied by selecting highest priority populations in the three OBoF regions based roughly on each region's proportional amount of productive habitat. Proposed priority rivers include three populations above Mactaquac Dam (these three tributaries represent 23.1% of the total habitat within the Canadian portion of the OBoF region), five from below (31.7%), and one population from the outer Fundy complex (1.0%). Distribution target criteria for river prioritization (**in order of importance**) are as follows:

1. **No evidence of extirpation**
    - Source: Available data (Clarke et al. 2014) and recent juvenile densities (Fig. 28)
    - Scoring: Non-extirpated = 3, absent in 2009 electrofishing survey = 0
2. **Unique and genetically-based traits**
    - Source: OBoF genetic analyses (O'Reilly et al. 2014)
    - Scoring: Known = 3, none or unknown = 0
3. **Recent presence and relative high density of wild Atlantic Salmon**
    - Source: mean densities, 2009 electrofishing survey (Fig. 28)
    - Scoring: High (>1 age class) = 3, Medium =2, Low=1, none or not assessed = 0
4. **Full connectivity between marine and spawning environments**
    - Source: Based on location above or below major dams (Clarke et al. 2014)
    - Scoring: Full connectivity = 3, restricted passage (<3 dams) = 2, restricted passage (≥3 Dams)= 1 and no access = 0
5. **High estimated productive capacity**
    - Source: Based on estimated amount of productive habitat (Marshall et al. 2014)
    - Scoring: >20,000 units =3, 10,000-20,000=2, <10,000=1, no access = 0
6. **Minimal relative impact by known threats.**
    - Source: Based on relative threat impact assessment (Clarke et al. 2014)
    - Scoring: Low impact = 3, Medium = 2, High =1
7. **Representative geographic variation/distribution**
    - Source: Selecting highest priority rivers/populations based on criteria 1-6 to represent the 3 regions of DU 16:
        - 3 Highest priority SJR tributaries above Mactaquac Dam (1 river)
        - 5 Highest priority rivers from below Mactaquac Dam
        - 1 Highest priority river from Outer Fundy complex

To weight scores, criteria 1-6 were multiplied to assign more priority for more important criteria. For example, scores for criterion 1 for each river were multiplied by 6, criterion 2 by 5, 3 by 4 and so on. Applying criteria 1-7 resulted in a proposed priority ranking for all OBoF DU rivers (Appendix 8). From this list, short-term distribution targets include:

- SJR above Mactaquac Dam, specific tributaries include:
    - Tobique, Shikatehawk, and Becaguimec[4]

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[4] Tobique scored for unique traits based on the presence of 'pre-smolt' phenotype and the documented accounts of the unique migration behaviour by the Serpentine River stock (upper tributary of the Tobique) see Clarke et al. (2014).

- Rivers from SJR below Mactaquac Dam include:
  - Canaan, Nashwaak, Hammond, Keswick, and Kennebecasis
- Outer Fundy complex include:
  - Digdeguash

The short-term distribution target is to support the persistence of salmon in the seven priority rivers known to historically contain Atlantic Salmon populations.

Long-Term

The long-term distribution target is to support the persistence of salmon in all 20 rivers known to historically contain Atlantic Salmon populations. It is unknown whether all 20 rivers are required to ensure the long-term persistence of the DU; however, a greater number of populations are expected to increase the chance of persistence of the DU.

Abundance Target

To be in compliance with DFO guidelines (DFO 2005), and to be consistent with the RPAs completed on other Designatable Units, the conservation requirement is proposed when setting the abundance target for OBoF population (DU). This is same approach that has been used in setting abundance targets for IBoF (DFO 2008), Southern Uplands (DFO 2013a), South Newfoundland (DFO 2012), and most recently Eastern Cape Breton (DFO 2013b). Using the conservation requirement of 2.4 eggs per m^2 of accessible productive habitat is consistent with the terminology used by Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC 1991) when developing the conservation egg requirement and for a limit reference point in DFO's Precautionary Approach framework (Gibson and Claytor 2013). Overall population size is positively related to population persistence for a range of fish species, which suggests that increasing population size is important for recovery. However, population size alone is not an indicator of population viability, and precisely how large populations need to be depends on their dynamics as they rebuild.

Short-Term

The short-term abundance target for the OBoF DU is to annually achieve the conservation egg requirement in all the seven priority rivers selected for distribution targets. Short-term distribution target rivers include the SJR upriver of Mactaquac Dam (specifically, Tobique, Shikatehawk, and Becaguimec tributaries), five rivers downriver of Mactaquac Dam (Keswick, Nashwaak, Canaan, Kennebecasis, and Hammond), and one river from the outer Fundy complex (Digdeguash). Combined, short-term target rivers represent 56% of the salmon habitat in the OBoF region. Using the most recent biological characteristic data for each complex of rivers (e.g., Table 7b for the complex tributaries of upriver of Mactaquac Dam), this target translates to approximately 54.4 million eggs which could be produced by 23,500 adult salmon (17,000 1SW and 6,500 MSW salmon) within the 22.62 million m^2 of productive habitat area (Table 18).

Long-Term

The long-term abundance target, based on 2.4 eggs per m^2, is 97 million eggs in the currently accessible 40.46 million m^2 of productive habitat area. This egg deposition could be produced by 41,200 adult salmon (29,700 1SW and 11,500 MSW salmon) based on average biological characteristics (Table 18). Currently accessible habitat includes all Canadian OBoF productive habitat area except the estimated 1.3 million m^2 of currently inaccessible habitat due to dams on the Monquart, Nackawic, and Musquash rivers. The abundance recovery targets established for the Southern Uplands DU also included the previously accessible habitat area upriver of 'man-made' structures (DFO 2013a) but this potential productive habitat has not been used when setting the long-term abundance target for the OBoF DU.

Recovery targets will need to be revisited as information about the dynamics of the recovering populations becomes available.

CONCLUSIONS

Overall, the available data on salmon in DU 16 indicates that populations are persisting at low abundance levels. This conclusion is consistent for all monitored life stages. The 1SW and MSW returns to counting facilities were the lowest on record in 2012. Wild smolt to 1SW and 2SW salmon return rates were both less than 0.4% on the Nashwaak River. In the past five years, estimated adult abundance on the Saint John River upriver of Mactaquac Dam and on the Nashwaak River has averaged about 7% (2-13%) and 22% (3- 37%) of their respective conservation requirements. The estimated egg deposition upriver of Mactaquac has declined at rates in excess of 80% over the last 15 years, while Nashwaak egg deposition has also declined but to a lesser degree (27-50%) over the same time period. Pre-smolt and smolt estimates contributing to the 2012 smolt class for the Tobique River were the highest since monitoring commenced in 2001, and the minimum smolt abundance estimate on the Nashwaak River was higher than 2011 but below the previous 5-year mean. Annual smolt production estimates for both rivers have been less than 0.6 smolts per 100 m^2 of productive habitat, and is low in comparison to 3.8 smolts per 100 m^2 (Symons 1979), which is sometimes used as a general reference value for rivers at or near the conservation. Juvenile densities in the Tobique and Nashwaak rivers were considerably below reference values (Elson's norm) in 2012. Estimated parr densities in both river systems have remained relatively constant (between 5-10 fish per 100 m^2) over the last decade. Adult returns to the Magaguadavic River were one MSW salmon in 2012, and have averaged less than 10 fish for the past decade. There has been no new adult abundance data to report for the St. Croix River since the fishway has not been monitored since 2006, but returns were expected to be extremely low. Decline rates in excess of 80% were predicted for the Magaguadavic River. Predicted declines are about 65% when considering total escapement of 1SW and MSW returning adults to DU 16 over the last 15 years. Electrofishing surveys conducted at 189 sites within most of the rivers or tributaries within the DU revealed that juveniles are still present in most of the tributaries but at low densities. The rivers with the highest mean densities were all tributaries of the Saint John River, which included: the Shikatehawk, Little Presquile, Keswick, Nashwaak, Canaan and Hammond tributaries.

Consistent with approaches taken for other Atlantic Salmon RPAs in Atlantic Canada, the proposed recovery target for the OBoF DU has both an abundance and distribution component. The short-term distribution target was based on seven criteria designed to maintain genotypic, phenotypic, and geographic representation of the DU while offering the best opportunity for recovery. The short-term distribution target is to support the persistence of Atlantic Salmon in the seven priority rivers. Abundance targets are set using the conservation egg requirement of 2.4 eggs per m^2 of productive habitat. The short-term abundance target for the OBoF DU is to annually achieve the conservation egg requirement in all the seven priority rivers selected for distribution targets. Combined, short-term target rivers represent 56% of the salmon habitat in the OBoF region. This target translates to approximately 54.4 million eggs, which could be produced by 23,500 adult salmon (17,000 1SW and 6,500 MSW salmon) within the 22.62 million m^2 of productive habitat area. The long-term abundance target, based on 2.4 eggs per m^2, is 97 million eggs in the currently accessible 40.46 million m^2 of productive habitat area. This egg deposition could be produced by 41,200 adult salmon (29,700 1SW and 11,500 MSW salmon).

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TABLES

Table 1: Estimated total (adjusted) returns of wild, hatchery, captive-reared and aquaculture 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, NB, 2012.

Sea-age	Components	Wild	Hatchery	Captive-Reared	Aquaculture	Total
1SW						
	Mactaquac counts[a]	56	28	0	0	84
	Mactaquac adjusted counts[b]	48	33	0	0	81
	By-catch[c]	0	0	0	0	0
	Totals	48	33	0	0	81
MSW						
	Mactaquac counts[a]	80	45	0	0	125
	Mactaquac adjusted counts[b]	69	59	0	0	128
	Illegal fishing below Mactaquac[c]	0	0	0	0	0
	By-catch[d]	2	2	0	0	4
	Totals	71	61	0	0	132

Key:

[a] Hatchery/wild origin per external characteristics in previous assessments; fishway closed Oct. 25, 2012.
[b] Adjusted by analyses of scales from sampled fish (Marshall and Jones 1996).
[c] No MSW salmon were estimated to have been removed by illegal gillnets set below the Mactaquac Dam in 2012.
[d] Estimated to be 1% of total 1SW returns and 2.5% total MSW returns and is considered to include losses to illegal fishing.

Table 2: Counts of wild, hatchery, landlocked (LL) and aquaculture origin Atlantic Salmon (as identified by fishway operators) trapped at fishways and/or fences in four rivers in southwest and central NB. Period (.) equals no data.

	Saint John						Nashwaak						Magaguadavic							St. Croix[c]						
	Wild		Hatchery				Wild		Hatchery				Wild		Hatchery		Aquaculture			Wild		Hatchery		Aquaculture		
Year	1SW	MSW	1SW	MSW	LL	Key	1SW	MSW	1SW	MSW	LL	Key	1SW	MSW	1SW	MSW	1SW	MSW	Key	1SW	MSW	1SW	MSW	1SW	MSW	Key
1967	1,181	1,271	0	0	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1968	1,203	770	0	0	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1969	2,572	1,749	0	0	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1970	2,874	2,449	94	0	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1971	1,592	2,235	336	37	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1972	784	4,831	246	583	.		259	859	.	.	.	e	.	.	.	.	.	.		.	.	.	.	.	.	
1973	1,854	2,367	1,760	475	.		596	1,956	.	.	.	e	.	.	.	.	.	.		.	.	.	.	.	.	
1974	3,389	4,775	3,700	1,907	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1975	5,725	6,200	5,335	1,858	.		1,223	1,036	.	.	.	e	.	.	.	.	.	.		.	.	.	.	.	.	
1976	6,797	5,511	7,694	1,623	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1977	3,504	7,257	6,201	2,075	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1978	1,584	3,034	2,556	1,951	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1979	6,234	1,993	3,521	892	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1980	7,555	8,157	9,759	2,294	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1981	4,571	2,441	3,782	1,089	.		.	.	.	.	.		.	.	.	.	.	.		.	.	.	.	.	.	
1982	3,931	2,254	2,292	728	34		.	.	.	.	.		.	.	.	.	.	.		53	15	27	3	.	.	df
1983	3,613	1,711	1,230	299	37		.	.	.	.	.		282	607	.	.	21	30		33	62	2	28	.	.	df
1984	7,353	7,011	1,304	806	26		.	.	.	.	.		255	512	.	.	.	.		120	40	63	17	.	.	df
1985	5,331	6,390	1,746	571	6		.	.	.	.	.		169	466	.	.	.	.		36	250	12	46	.	.	df
1986	6,347	3,655	699	487	0		.	.	.	.	.		.	.	.	.	.	.		31	128	29	130	.	.	df
1987	5,106	3,091	2,894	344	19		.	.	.	.	.		.	.	.	.	.	.		43	147	181	21	.	.	df
1988	8,062	1,930	1,129	670	310		.	.	.	.	.		291	398	.	.	.	.		45	22	55	274	.	.	df
1989	8,417	3,854	1,170	437	128		.	.	.	.	.		.	.	.	.	.	.		46	19	95	73	.	.	df
1990	6,486	3,163	1,421	756	681	a	.	.	.	.	.		.	.	.	.	.	.		11	40	4	54	.	.	df
1991	5,415	3,639	2,160	587	190	a	.	.	.	.	.		.	.	.	.	.	.		30	83	42	52	.	.	df
1992	5,729	3,522	1,935	681	0	a	.	.	.	.	.		155	139	.	.	83	62	bd	.	.	.	.	.	.	
1993	2,873	2,601	1,034	379	0	a	72	113	11	42	.	de	112	125	.	.	96	52	bd	3	30	5	66	.	.	d
1994	2,133	1,713	1,180	493	83	a	376	251	27	23	.	de	69	61	.	.	1,059	81	bd	24	19	23	18	97	.	
1995	2,429	1,681	2,541	598	50	a	544	294	25	14	.	de	49	30	.	.	491	168	bd	7	14	7	19	7	6	d
1996	1,552	2,413	4,603	726	24	a	854	391	86	38	.	de	48	21	.	.	174	20	bde	10	32	13	77	15	5	d
1997	380	1,147	2,689	629	44	a	332	339	38	27	.	d	35	24	.	.	59	23	bd	7	8	26	2	11	16	d
1998	476	367	4,413	624	28	a	464	142	1	9	.	de	28	3	.	.	211	3	bd	12	6	20	3	14	11	df
1999	700	1,112	2,511	680	22	a	303	84	2	0	.	de	19	5	.	.	80	10	bd	7	2	1	3	23	0	df
2000	1,408	393	1,573	200	24	a	428	161	0	0	.	de	13	1	.	.	25	2	bd	0	0	15	5	30	0	df
2001	730	680	942	521	39	a	242	271	2	1	3	d	8	9	.	.	120	4	bd	0	0	13	7	33	23	df
2002	709	212	1,616	178	19	a	342	73	1	6	0	d	7	0	.	.	29	0	bd	0	0	14	6	2	4	d
2003	443	279	838	464	1	a	181	82	7	3	2	de	3	3	.	.	14	2	bd	0	0	13	2	3	3	df
2004	863	446	562	296	2	a	473	168	13	4	1	de	2	0	.	.	0	17	bd	1	0	5	4	0	4	d
2005	862	269	264	94	2		405	94	20	3	2	ade	5	0	4	0	62	1	bd	0	0	2	4	30	3	d
2006	823	303	467	68	6	a	376	116	29	2	1	de	14	3	9	1	4	2	bd	0	0	2	2	4	3	d
2007	574	204	334	111	3		218	95	3	6	0	de	4	0	0	0	4	1	bd	n/a	.	.	.	.	.	
2008	886	163	871	137	.		516	77	10	1	0	de	4	0	0	0	2	4	bd	n/a	.	.	.	.	.	
2009	449	361	162	179	1		188	206	11	7	0	de	1	2	2	1	13	1	bd	n/a	.	.	.	.	.	
2010	1,870	321	499	105	7	a	836	142	18	3	1	de	0	0	12	0	23	0	bd	n/a	.	.	.	.	.	
2011	580	288	408	394	5		396	226	21	6	1	de	0	0	8	11	17	0	bd	n/a	.	.	.	.	.	
2012	48	69	33	59	350		16	39	0	0	6	de	0	1	0	0	18	0	bd	n/a	.	.	.	.	.	

Key: a- Small numbers of aquaculture fish, see tables 3,4a & b. b- Aquaculture. c- Hatchery designation to be reviewed; sea-cage fish could be among hatchery fish prior to 1994. d- Corrected by scale analysis. e- Partial count. f-Breakdown changed from Jones et al. 2004, n/a - no monitoring.

Table 3: Estimated total returns and egg depositions of wild, hatchery and aquaculture 1SW and MSW salmon destined for Mactaquac Dam, Saint John River, 1970-2012. Period (.) equals no data.

	Wild		Hatchery[a]		Total (W+H)		Aquaculture[b]		Total
Year	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	Egg Deposit
1970	3,057	5,712	100	0	3,157	5,712	.	.	6,743,577
1971	1,709	4,715	365	77	2,074	4,792	.	.	9,686,229
1972	908	4,899	285	592	1,193	5,491	.	.	25,380,372
1973	2,070	2,518	1,965	505	4,035	3,023	.	.	15,326,312
1974	3,656	5,811	3,991	2,325	7,647	8,136	.	.	39,357,968
1975	6,858	7,441	6,374	2,210	13,232	9,651	.	.	54,684,280
1976	8,147	8,177	9,074	2,302	17,221	10,479	.	.	36,292,706
1977	3,977	9,712	6,992	2,725	10,969	12,437	.	.	50,883,354
1978	1,902	4,021	3,044	2,534	4,946	6,555	.	.	28,813,466
1979	6,828	2,754	3,827	1,188	10,655	3,942	.	.	18,023,742
1980	8,482	10,924	10,793	2,992	19,275	13,916	.	.	58,362,594
1981	6,614	5,766	5,627	2,728	12,241	8,494	.	.	17,778,521
1982	5,174	5,528	3,038	1,769	8,212	7,297	.	.	18,882,016
1983	4,555	5,783	1,564	1,104	6,119	6,887	.	.	9,686,229
1984	8,311	9,779	1,451	1,115	9,762	10,894	.	.	40,216,241
1985	6,526	10,436	2,018	875	8,544	11,311	.	.	41,197,125
1986	7,904	6,128	862	797	8,766	6,925	.	.	26,483,866
1987	5,909	4,352	3,328	480	9,237	4,832	.	.	24,276,877
1988	8,930	2,625	1,250	912	10,180	3,537	.	.	14,835,870
1989	9,522	4,072	1,339	469	10,861	4,541	.	.	27,955,192
1990	7,263	3,329	1,533	575	8,796	3,904	8	221	25,135,151
1991	6,256	4,491	2,439	700	8,695	5,191	56	24	25,748,203
1992	6,683	4,104	2,223	778	8,906	4,882	34	16	23,786,435
1993	3,213	2,958	1,156	425	4,369	3,383	0	6	15,081,091
1994	2,276	1,844	1,258	503	3,534	2,347	0	28	11,402,776
1995	2,168	1,654	2,907	599	5,075	2,253	4	102	13,477,345
1996	1,326	2,309	5,394	1,002	6,720	3,311	3	10	18,277,454
1997	343	1,128	2,912	843	3,255	1,971	0	0	9,780,394
1998	341	320	4,641	647	4,982	967	0	4	5,912,196
1999	472	837	2,785	967	3,257	1,804	7	13	10,087,002
2000	1,343	277	1,725	267	3,068	544	3	3	3,564,850
2001	686	644	1,014	562	1,700	1,206	12	2	6,482,071
2002	634	199	1,724	177	2,358	376	5	8	1,867,321
2003	381	240	921	511	1,302	751	2	1	3,912,005
2004	864	400	623	312	1,487	712	0	1	4,067,287
2005	863	254	296	96	1,159	350	0	0	1,916,912
2006	797	283	536	64	1,333	347	1	0	1,840,252
2007	492	205	411	131	903	336	0	0	1,550,959
2008	796	143	1005	138	1,801	281	0	0	1,528,238
2009	437	337	176	221	613	558	0	0	2,769,173
2010	1,708	312	686	148	2,394	460	0	27	2,448,140
2011	582	294	437	384	1,019	678	0	0	4,107,234
2012	48	71	33	61	81	132	0	0	544,251

Key:

[a] Excludes: 3 Captive-reared (CR) MSW fish (2006), 1 CR 1SW fish (2007), 6 CR MSW fish (2009), 2 1SW and 2 MSW CR fish (2010) and 5 MSW CR fish (2011).

[b] Years 1990-1994, 1SW and MSW classification based on lengths and count data; 1995-2005, count raised by estimated removals downstream of Mactaquac and adjusted according to ages from scale samples.

Table 4a: Estimated total number of 1SW returns to the Saint John River, 1975-2012, from hatchery-reared smolts released at Mactaquac Dam, 1974-2011. Prop 1-yr= proportion of total releases age-1. Period (.) equals no data.

Releases			Returns									
			Mactaquac								% return	
Year	Smolts	Prop 1-yr	Year	Mig ch.	Dam	Native fishery	Angled main SJ	By-catch	Commercial	Total[a]	Unadj	Adj[bcf]
				(combined)								
1974	337,281	0.00	1975	1,771	3,564	28	977	34	.	6,374	1.890	.
1975	324,186	0.06	1976	2,863	4,831	219	1,129	32	.	9,074	2.799	.
1976	297,350	0.14	1977	1,645	4,533	36	708	70	.	6,992	2.351	.
1977	293,132	0.26	1978	777	1,779	49	369	70	.	3,044	1.038	.
1978	196,196	0.16	1979	799	2,722	100	186	20	.	3,827	1.951	.
1979	244,012	0.09	1980	3,072	6,687	335	640	59	.	10,793	4.423	.
1980	232,258	0.12	1981	921	2,861	139	350	.	1,356	5,627	2.423	.
1981	189,090	0.08	1982	828	1,464	64	267	.	415	3,038	1.607	.
1982	172,231	0.06	1983	374	857	39	69	.	225	1,564	0.908	.
1983	144,549	0.22	1984	476	828	36	63	48	.	1,451	1.004	0.976
1984	206,462	0.28	1985	454	1,288	82	128	66	.	2,018	0.977	0.920
1985	89,051	1.00	1986	64	635	53	93	17	.	862	0.968	0.868
1986	191,495	1.00	1987	152	2,063	74	222	52	.	2,563	1.338	1.170
1987	113,439	1.00	1988	(717)		15	46	16	.	794	0.700	0.672
1988	142,195	1.00	1989	(1,018)		0	107	23	.	1,148	0.807	0.763
1989	238,204	0.98	1990	(903)		0	57	20	.	980	0.411	0.401
1990	241,078	0.98	1991	(1,490)		88	108	35	.	1,721	0.714	0.649
1991	178,127	0.97	1992	(1,132)		26	135	26	.	1,319	0.740	0.688
1992	204,836	1.00	1993	(779)		11	60	17	.	867	0.423	0.406
1993	221,403	1.00	1994	(841)		37	0	18	.	896	0.405	0.393
1994	225,037	1.00	1995	(1,509)		15		15	.	1,539	0.684	0.661
1995	[d]251,759	1.00	1996	(2,649)		215	0	29	.	2,893	1.149	1.140
1996	286,400	1.00	1997	(1,543)		58	0	16	.	1,617	0.565	0.558
1997	286,485	1.00	1998	(2,112)		0	0	21	.	2,133	0.745	0.745
1998	297,012	1.00	1999	(1,672)		0	0	17	.	1,689	0.569	0.468
1999	305,073	1.00	2000	(1,403)		0	0	14	.	1,417	0.464	0.464
2000	311,825	1.00	2001	(839)		0	0	8	.	847	0.272	0.272
2001	305,321	1.00	2002	(1,358)		0	0	14	.	1,372	0.449	0.449
2002	241,971	1.00	2003	(815)		0	0	8	.	823	0.340	0.340
2003	155,701	1.00	2004	(499)		0	0	5	.	504	0.324	0.324
2004	52,178	1.00	2005	(197)		0	0	2	.	199	0.381	0.381
2005	77,271	1.00	2006	(426)		0	0	4	.	430	0.556	0.384
2006	[e]113,847	1.00	2007	(273)		0	0	3	.	276	0.242	0.213
2007	[e]84,088	1.00	2008	(686)		0	0	7	.	696	0.828	0.703
2008	[g]55,253	1.00	2009	(97)		0	0	1	.	98	0.177	0.125
2009	[e]27,314	1.00	2010	(444)		0	0	5	.	448	1.640	1.435
2010	[e]35,050	1.00	2011	(51)		0	0	0	.	51	0.146	0.120
2011	[e]24,135	1.00	2012	(4)		0	0	0	.	4	0.017	0.017
2012	[e]4,500	1.00	2013	.		.	.	.	.	.	.	.

Key:

[a] Includes some returns from smolts stocked downriver of Mactaquac or escaped from sea-cages (Table 3: as determined from erosion of margins of upper and lower caudal fins).

[b] Adjusted return rates exclude smolts stocked downriver from Mactaquac (Marshall 1989) and fish of probable sea-cage origin. (Marginal numbers of returns from approx. 5,000 age 2.1 smolts, 1989-1991 are not included; no returns from tagged smolts released to the Nashwaak River, 1992 or 1997; 1997 count yielded 2 tagged 1SW fish from among 2,000 tagged smolts released to the Nashwaak in 1996 (9,017 smolts total).

[c] 1997 adjustment to return years 1995-97, based on adipose-clipped age1.1 returns from age-0+ fall fingerlings stocked above Mactaquac, 1993-95. Total estimated returns number 22, 22 and 10 in 1995, 1996 and 1997, respectively.

[d] Revised "smolts released" includes 11,177 age-1 smolts released to the migration channel from Saint John Hatchery.

[e] Smolts were from the Tobique River captive-reared program.

[f] 2006-08 adjustment to return year based on adipose-clipped age 1.1 returns from age-0+ fall fingerlings stocked above Mactaquac in 2004-06. Total estimated returns numbered 133 fish in 2006, 34 fish in 2007 and 105 fish in 2008.

[g] 2008 smolts were 36,394 from sea-run crosses and 18,859 from captive-reared crosses.

Table 4b: Estimated total number of virgin 2SW returns to the Saint John River, 1976-2012, from hatchery-reared smolts released at Mactaquac Dam, 1974-2010. Period (.) equals no data.

Releases			Returns									
				Mactaquac							% return	
Year	Smolts	Prop 1-yr	Year	Mig ch (combined)	Dam	Native fishery	Angled main SJ	By-catch	Com-mercial	Total[a]	Unadj	Adj[bcf]
1974	337,281	0.00	1976	310	1,313	392	267	20	.	2,302	0.683	.
1975	324,186	0.06	1977	341	1,727	206	417	34	.	2,725	0.841	.
1976	297,350	0.14	1978	223	1,728	368	165	50	.	2,534	0.852	.
1977	293,132	0.26	1979	145	747	210	65	21	.	1,188	0.405	.
1978	196,196	0.16	1980	302	1,992	506	146	46	.	2,992	1.525	.
1979	244,012	0.09	1981	126	963	252	125	.	1,262	2,728	1.118	.
1980	232,258	0.12	1982	88	640	462	181	.	398	1,769	0.762	.
1981	189,090	0.08	1983	44	255	76	17	.	712	1,104	0.584	.
1982	172,231	0.06	1984	84	722	201	5	103	.	1,115	0.647	0.560
1983	144,549	0.22	1985	73	492	189	5	116	.	875	0.605	0.553
1984	206,462	0.28	1986	16	471	266	4	40	.	797	0.386	0.346
1985	89,051	1.00	1987	4	338	110	4	24	.	480	0.539	0.453
1986	191,495	1.00	1988	(511)		150	0	35	.	696	0.363	0.354
1987	113,439	1.00	1989	(379)		0	0	20	.	399	0.352	0.330
1988	142,195	1.00	1990	(480)		0	0	25	.	505	0.355	0.170
1989	238,204	0.98	1991	(359)		62	0	46	.	467	0.196	0.173
1990	241,078	0.98	1992	(590)		58	0	32	.	680	0.282	0.256
1991	178,127	0.97	1993	(242)		16	0	11	.	269	0.151	0.145
1992	204,836	1.00	1994	(303)		10	0	23	.	336	0.164	0.159
1993	221,403	1.00	1995	(398)		5	0	11	.	414	0.187	0.187
1994	225,037	1.00	1996	(567)		18	0	15	.	600	0.267	0.267
1995	[d]251,759	1.00	1997	(412)		45	0	12	.	469	0.186	0.186
1996	286,400	1.00	1998	(229)		0	0	6	.	235	0.082	0.082
1997	286,485	1.00	1999	(554)		0	0	14	.	568	0.198	0.198
1998	297,012	1.00	2000	(173)		0	0	4	.	177	0.060	0.060
1999	305,073	1.00	2001	(462)		0	0	12	.	474	0.155	0.155
2000	311,825	1.00	2002	(142)		0	0	4	.	146	0.047	0.047
2001	305,321	1.00	2003	(443)		0	0	11	.	454	0.149	0.149
2002	241,971	1.00	2004	(265)		0	0	7	.	272	0.112	0.112
2003	155,701	1.00	2005	(78)		0	0	2	.	80	0.051	0.051
2004	52,178	1.00	2006	(44)		0	0	1	.	45	0.086	0.086
2005	77,271	1.00	2007	(89)		0	0	2	.	91	0.118	0.110
2006	[e]113,847	1.00	2008	(71)		0	0	2	.	73	0.064	0.052
2007	[e]84,088	1.00	2009	(139)		0	0	4	.	143	0.170	0.137
2008	[g]55,253	1.00	2010	(76)		0	0	2	[h]11	89	0.161	0.148
2009	[e]27,314	1.00	2011	(34)		0	0	1	.	35	0.128	0.128
2010	[e]35,050	1.00	2012	(22)		0	0	1	.	23	0.066	.
2011	[e]24,135	.	.	.		.	.	.	.	.	.	.

Key:

[a] Includes some returns from smolts stocked downriver of Mactaquac or escaped from sea-cages (Table 3: erosion of margins of upper and lower caudal fins).

[b] Adjusted return rates exclude smolts stocked downriver from Mactaquac (Marshall 1989) and fish of probable sea-cage origin. (Marginal numbers of returns from approx. 5,000 age 2.1 smolts, 1989-1991 are not included; no returns from tagged smolts released to the Nashwaak River, 1992; possibly 3 returns from 12,516 smolts >12 cm to Nashwaak in 1993; no returns from 15,059 stocked in the Nashwaak in 1994 and 2 returns from 3,989 tagged [13,283 total] in 1995.

[c] 1997 adjustment to return year 1997 based on adipose-clipped age 1.2 returns from age-0+ fall fingerlings stocked above Mactaquac in 1994. Total estimated returns numbered 9 fish in 1997.

[d] Revised "smolts released" includes 11,177 age-1 smolts released to the migration channel from Saint John Hatchery.

[e] Smolts were from the Tobique River captive-reared program.

[f] 2007-08 adjustment to return year based on adipose-clipped age 1.2 returns from age-0+ fall fingerlings stocked above Mactaquac in 2006-07. Total estimated returns numbered 6 fish in 2007 and 14 fish in 2008.

[g] 2008 smolts were 36,394 from sea-run crosses and 18,859 from captive-reared crosses.

[h] Estimated to have been removed by poachers (not commercial fishers) below Mactaquac Dam.

Table 5a: Estimated removals of 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, 2012.

	1SW			MSW		
Components	**Wild**	**Hatch**	**Total**	**Wild**	**Hatch**	**Total**
Passed above Tinker	4	2	6	10	6	16
Mortality at Beechwood, Tobique	0	0	0	2	2	4
Tobique Barrier mortalities	0	0	0	0	0	0
Hatchery broodfish	0	0	0	0	0	0
Sorting or Handling Mortalities	0	0	0	3	1	4
Illegal fishing	3	2	5	3	4	7
By-catch[a]	0	0	0	2	2	4
Totals	**7**	**4**	**11**	**20**	**15**	**35**

Key:
[a] Wild:hatchery composition per adjusted counts and assumed availability.

Table 5b: Numbers of adult salmon [inc. females(F)] released above Tinker Dam on the Aroostook River and above Grand Falls on the mainstem Saint John River, 1983-2012.

	Tinker								Grand Falls			
	Trucked				Fishway[a b]		Total		Trucked			
Year	**1SW**	**(F)**	**MSW**	**(F)**	**1SW**	**MSW**	**1SW**	**MSW**	**1SW**	**(F)**	**MSW**	**(F)**
1983	34	.	0	.	.	.	34	0	.	.	.	.
1984	58	.	29	.	.	.	58	29	.	.	.	.
1985	65	.	24	.	.	.	65	24	.	.	12	(10)
1986	50	.	0	.	.	.	50	0	.	.	.	.
1987	77	.	9	.	.	.	77	9	.	.	.	.
1988	70	.	30	.	17?	39?	70	30	.	.	.	.
1989	88	(6)	35	(30)	81	22	169	57	.	.	.	.
1990	0	.	0	.	45	18	45	18	.	.	.	.
1991	50	(3)	50	(47)	39	0	89	50	90	(5)	50	(47)
1992	225	(24)	90	(84)	117	6	342	96	230	(16)	110	(106)
1993	85	(17)	71	(63)	50	13	135	84	109	(12)	64	(53)
1994	105	(6)	16	(12)	14	5	119	21	62	(8)	17	(14)
1995	100	(11)	40	(36)	20	2	120	42	0	.	0	.
1996	100	(8)	40	(40)	53	12	153	52	0	.	0	.
1997	50	(5)	20	(19)	6	6	56	26	0	.	0	.
1998	50	(6)	0	(0)	26	4	76	4	0	.	0	.
1999	50	(6)	0	.	14	10	64	10	0	.	0	.
2000	52	(10)	0	.	11	6	63	6	0	.	0	.
2001	52	(4)	0	.	14	14	66	14	0	.	0	.
2002	50	(1)	0	.	6	1	56	1	0	.	0	.
2003	49	(8)	0	.	1	1	50	1	0	.	0	.
2004	49	(1)	2	(2)	0	0	49	2	0	.	0	.
2005	0	.	0	.	6	2	6	2	0	.	0	.
2006	0	.	0	.	15	0	15	0	0	.	0	.
2007	0	.	0	.	5	1	5	1	0	.	0	.
2008	0	.	0	.	20	24	20	24	0	.	0	.
2009	0	.	0	.	11	5	11	5	0	.	0	.
2010	0	.	0	.	22	10	22	10	0	.	0	.
2011	0	.	0	.	23	28	23	28	0	.	0	.
2012	0	.	0	.	6	29	6	29	.	.	.	.

Key:
[a] Sea-age based on fork length measurements & differs from that ascribed by Tinker Fishway operator.
[b] 19 of the 24 (2008), 19 of the 28 (2011),13 of the 29 (2012) MSW fish were of captive-reared origin.

Table 6: Estimated returns, removals and spawning escapement of 1SW and MSW salmon destined for upriver of Mactaquac Dam, Saint John River, 2012. Period (.) equals no data.

Sea-age	Components	Wild	Hatch	Total
1SW	Returns	48	33	81
	Removals[a]	7	4	11
	Spawners	41	29	70
	Conservation requirement	.	.	4,900
	% of requirement	.	.	1
MSW	Returns	71	61	132
	Removals[a]	20	15	35
	Spawners	51	46	97
	Conservation requirement	.	.	4,900
	% of requirement	.	.	2

Key:

[a] Refer to Table 5a for details.

Table 7a: Number, biological characteristics and estimated number of eggs from wild 1SW and MSW salmon released upriver of Mactaquac Dam, 1996-2012.

Sea-Age Origin	Year	Female Mean Length (cm)	Estimated Fecundity	Prop Female	Total (M+F) Counts Escape	Total Eggs	Prop Total
Wild 1SW	1996	58.8	3,587	0.132	1,082	512,310	0.03
	1997	61.3	3,927	0.061	313	74,979	0.01
	1998	58.5	3,550	0.135	311	148,573	0.03
	1999	62.3	4,066	0.109	432	192,076	0.02
	2000	59.8	3,717	0.177	1,208	795,471	0.22
	2001	59.6	3,692	0.112	548	225,894	0.03
	2002	59.9	3,728	0.126	544	254,698	0.14
	2003	59.7	3,701	0.137	281	142,091	0.04
	2004	59.2	3,635	0.120	759	330,803	0.10
	2005	58.2	3,506	0.068	804	190,824	0.08
	2006	60.2	3,767	0.064	736	178,759	0.10
	2007	56.0	3,239	0.048	440	67,731	0.04
	2008	60.5	3,810	0.038	716	103,005	0.07
	2009	60.6	3,825	0.079	394	118,412	0.04
	2010	60.1	3,748	0.040	1,664	250,008	0.10
	2011	61.0	3,879	0.034	546	73,033	0.02
	2012	60.0	3,741	0.019	46	3,247	0.01
	Mean	**59.8**	**3,713**	**0.088**			**0.06**
Wild MSW	1996	78.6	7,313	0.861	1,700	10,704,039	0.59
	1997	77.0	6,896	0.949	786	5,143,823	0.53
	1998	79.7	7,617	0.929	188	1,330,139	0.22
	1999	78.0	7,146	0.953	582	3,963,315	0.39
	2000	77.9	7,131	0.953	129	877,003	0.25
	2001	78.0	7,149	0.947	470	3,181,509	0.49
	2002	79.5	7,557	0.896	92	623,097	0.33
	2003	77.3	6,981	0.946	161	1,063,337	0.27
	2004	78.9	7,395	0.816	343	2,070,079	0.62
	2005	77.1	6,930	0.900	193	1,203,131	0.71
	2006	78.2	7,206	0.965	182	1,265,022	0.69
	2007	76.6	6,807	0.821	150	838,424	0.54
	2008	76.4	6,758	0.974	91	599,074	0.39
	2009	77.4	6,996	0.765	277	1,482,541	0.54
	2010	77.4	6,996	0.928	233	1,511,948	0.62
	2011	77.0	6,906	0.941	264	1,715,191	0.42
	2012	76.3	6,733	0.917	57	351,800	0.65
	Mean	**77.7**	**7,089**	**0.909**			**0.48**

Table 7b: Number, biological characteristics and estimated number of eggs from hatchery 1SW and MSW salmon released upriver of Mactaquac Dam, 1996-2012. 'Hatchery' - meaning sea-run returns likely released as either parr or smolt but possibly fry (Appendix 2) based on interpretation of scale patterns, fin erosion or fin clips.

Sea-Age Origin	Year	Female Mean Length (cm)	Estimated Fecundity	Prop Female	Total (M+F) Counts Escape	Total Eggs	Prop Total
Hatchery 1SW	1996	58.8	3,584	0.118	4,394	1,858,276	0.10
	1997	62.0	4,021	0.092	2,429	898,565	0.09
	1998	58.6	3,551	0.113	4,311	1,734,600	0.29
	1999	59.5	3,672	0.101	2,530	940,495	0.09
	2000	58.0	3,486	0.089	1,587	493,507	0.14
	2001	60.8	3,855	0.041	915	144,907	0.02
	2002	60.2	3,769	0.047	1,621	287,235	0.15
	2003	58.1	3,494	0.073	855	218,951	0.06
	2004	59.6	3,688	0.062	580	132,273	0.02
	2005	61.4	3,935	0.037	256	37,589	0.03
	2006	60.5	3,803	0.041	522	82,202	0.04
	2007	56.2	3,262	0.050	392	63,748	0.04
	2008	60.6	3,823	0.046	958	167,199	0.11
	2009	61.3	3,925	0.060	165	38,550	0.01
	2010	61.0	3,879	0.006	675	15,048	0.01
	2011	62.2	4,046	0.029	402	47,145	0.01
	2012	62.0	4,021	0.103	25	10,400	0.02
	Mean	**60.0**	**3,754**	**0.065**			**0.07**
Hatchery MSW	1996	77.0	6,906	0.921	818	5,202,829	0.28
	1997	77.8	7,102	0.931	554	3,663,027	0.37
	1998	77.3	6,976	0.881	439	2,698,884	0.46
	1999	77.5	7,021	0.940	756	4,991,116	0.49
	2000	77.6	7,051	0.982	202	1,398,869	0.39
	2001	77.0	6,903	0.895	474	2,929,761	0.45
	2002	78.4	7,263	0.826	117	702,291	0.38
	2003	76.7	6,831	0.924	394	2,487,626	0.64
	2004	77.9	7,133	0.785	274	1,534,132	0.26
	2005	76.3	6,733	0.901	80	485,368	0.17
	2006	77.0	6,898	0.949	48	314,269	0.17
	2007	76.6	6,807	0.783	109	581,056	0.37
	2008	76.8	6,856	0.829	116	658,960	0.43
	2009	77.4	7,003	0.827	195	1,129,670	0.41
	2010	77.4	7,003	0.848	113	671,136	0.27
	2011	77.4	7,006	0.924	351	2,271,865	0.55
	2012	75.3	6,495	0.706	39	178,804	0.33
	Mean	**77.1**	**6,940**	**0.874**			**0.38**

Table 7c: Number, biological characteristics and estimated number of eggs from captive-reared salmon released upriver of Mactaquac Dam, 2003-2012. Period (.) equals no data.

Age	Year	Female Mean Length (cm)	Estimated Fecundity	Prop Female	Total (M+F) Counts Escape	Total Eggs	Prop Total
1 year adult	2003	48.6	2,817	0.588	386	639,459	1.00
	2004	51.6	3,205	0.426	207	282,630	0.09
	2005	48.3	2,776	0.569	202	319,240	0.06
	2006	48.2	2,764	0.344	223	211,878	0.04
	2007	49.3	2,900	0.534	267	413,153	0.12
	2008	.	.	0.000	69	0	-
	2009	48.4	2,788	0.141	156	61,336	0.01
	2010	46.6	2,576	0.475	381	466,256	0.14
	2011	47.4	2,668	0.465	331	410,872	0.11
	2012	.	.	.	0	.	.
	Mean	**48.6**	**2,812**	**0.394**			**0.18**
2 year adult	2003	.	.	.	0	.	.
	2004	60.8	4,787	0.749	780	2,798,178	0.91
	2005	65.6	5,902	0.830	847	4,149,106	0.80
	2006	60.0	4,623	0.790	797	2,909,082	0.61
	2007	61.8	5,001	0.693	414	1,434,892	0.40
	2008	59.0	4,426	0.765	597	2,021,355	0.72
	2009	61.9	5,022	0.688	458	1,581,930	0.34
	2010	57.8	4,202	0.968	401	1,630,782	0.50
	2011	59.3	4,477	0.691	379	1,172,401	0.32
	2012	61.3	4,893	0.627	1056	3,239,166	0.59
	Mean	**60.8**	**4,815**	**0.756**			**0.61**
3 year adult	2003	.	.	.	0	.	.
	2004	.	.	.	0	.	.
	2005	66.0	6,006	0.906	128	696,696	0.13
	2006	76.0	9,288	0.818	143	1,086,696	0.23
	2007	77.0	9,702	0.754	114	834,372	0.23
	2008	70.4	7,276	0.766	141	785,808	0.28
	2009	70.3	7,244	0.755	322	1,760,292	0.37
	2010	72.9	8,113	0.658	79	421,876	0.13
	2011	75.1	8,923	0.681	135	820,916	0.22
	2012	69.2	6,905	0.741	232	1,187,660	0.22
	Mean	**72.1**	**7,932**	**0.760**			**0.23**
Repeat Spawners	2003	.	.	.	0	.	.
	2004	.	.	.	0	.	.
	2005	73.0	8,141	0.128	39	40,705	0.01
	2006	80.3	11,203	0.437	119	582,556	0.12
	2007	70.7	7,371	0.605	195	869,778	0.24
	2008	67.0	6,273	0.022	90	12,546	0.00
	2009	70.5	7,307	0.433	413	1,307,953	0.28
	2010	76.3	9,414	0.471	170	753,120	0.23
	2011	77.6	9,952	0.560	232	1,293,760	0.35
	2012	75.0	8,891	0.741	162	1,066,920	0.19
	Mean	**73.8**	**8,569**	**0.425**			**0.15**

Table 8: Summary of declines in adult Atlantic Salmon returns and escapement for three populations and DU 16. The regression method is a log-linear model fit via least squares. The step function is the change in the 5-year mean population size ending on the years given in the time period column (the number of years differs between the methods). The standard errors (SE) and 95% confidence intervals (C.I.) are shown. Fifteen years corresponds to about three generations. A negative value for the decline rate indicates an increasing population size. Model fits are shown in figures 6, 21, 29, and 32.

					Log-linear Model						Ratio Method		
Population	Time Period	No. of Years	Slope	(SE)	1 Yr. decline rate (%)	95% C.I.		Decline over time period (%)	95% C.I.		Decline over time period (%)	95% C.I.	
Mactaquac - Wild 1SW Returns	1997-2012	15	-0.04	0.05	4.18	-5.46	12.94	47.30	-122.12	87.50	53.52	-85.81	87.88
Mactaquac - Hatchery 1SW Returns	1997-2012	15	-0.22	0.04	19.50	12.37	26.05	96.14	86.20	98.92	90.81	68.65	96.89
Mactaquac - Wild MSW Returns	1997-2012	15	-0.07	0.03	7.05	1.51	12.27	66.59	20.45	85.97	83.47	60.83	92.69
Mactaquac - Hatchery MSW Returns	1997-2012	15	-0.12	0.04	11.37	4.12	18.08	83.66	46.80	94.98	77.01	57.83	87.28
Mactaquac - Total Wild Returns	1997-2012	15	-0.05	0.04	5.23	-1.98	11.93	55.33	-34.22	85.13	69.25	6.74	89.68
Mactaquac – Total Hatchery Returns	1997-2012	15	-0.18	0.03	16.68	10.77	22.02	93.53	81.91	97.68	87.00	66.84	94.49
Mactaquac 1SW Returns	1997-2012	15	-0.15	0.04	14.17	6.93	20.84	89.89	65.97	97.00	83.80	48.81	94.49
Mactaquac MSW Returns	1997-2012	15	-0.10	0.03	9.17	3.69	14.34	76.38	43.13	90.19	81.92	65.04	90.28
Mactaquac Total Returns	1997-2012	15	-0.13	0.03	12.31	6.72	17.56	86.05	64.79	94.48	82.03	56.63	92.09
Mactaquac Total Escapement	1997-2012	15	-0.11	0.03	10.36	4.41	15.94	80.60	49.12	92.60	82.99	64.44	91.49
Nashwaak 1SW Returns	1997-2012	15	-0.04	0.06	3.89	-8.24	14.67	44.89	-227.93	90.74	46.97	-144.71	88.48
Nashwaak MSW Returns	1997-2012	15	-0.01	0.04	1.39	-5.83	8.12	18.93	-133.96	71.91	49.95	-5.28	75.86
Nashwaak Total Returns	1997-2012	15	-0.02	0.05	2.05	-7.46	10.72	26.74	-194.06	81.75	41.44	-85.81	81.27
Nashwaak Total Escapement	1997-2012	15	-0.02	0.04	2.07	-6.60	10.04	26.93	-160.97	79.54	49.62	-29.32	80.07
Magaguadavic Total Returns	1997-2012	15	-0.11	0.05	10.24	0.33	19.17	80.23	4.82	95.90	91.58	76.46	96.89
DU 16 1SW	1997-2012	15	-0.09	0.05	8.41	-1.60	17.43	73.21	-26.83	94.34	68.25	-26.31	91.49
DU 16 MSW	1997-2012	15	-0.05	0.03	4.80	-1.48	10.68	52.17	-24.59	81.64	68.31	34.99	84.27
DU 16 Total	1997-2012	15	-0.07	0.04	6.51	-1.29	13.70	63.54	-21.27	89.04	64.77	-1.07	87.28

Table 9a: Drainage area and freshwater habitat area (100 m^2 units) estimates within DU 16. The drainage area and potential habitat area on the Saint John River above Grand Falls is excluded. Period (.) equals no data.

Location	Tributary / Sub-tributary	DU16 (CANADA ONLY) Area (100 m²) units ACC. Prod. (>0.12%)	% of Prod. Habitat DU 16	Area (100 m²) units INACC. Prod.	CANADA and U.S. WATERS Drainage Area (km²)	% Drainage Area in NB	Area (100 m²) units ACC. Prod. (>0.12%)	% of Prod. Habitat in Drainage	U.S. ONLY Est. Area (100 m²) units Prod.	Area (100 m²) units INACC. Prod.	Prod. Habitat Ref. or Proxy Riv.
Saint John River, Upriver of Mactaquac Dam											
1	Upriver of Mactaquac Dam										
1.1	Salmon R.	12,754	3.2%		573	100%	12,754	2.6%			1
1.2	Mainstem-Aroostook to Grand Falls	5,400	1.3%		100		5,400	1.1%			1
1.3	Aroostook R.	1,221	0.3%		6,327	2%	61,037	12.3%	59,816		2
1.4	Tobique R.	78,562	19.4%		4,330	100%	78,562	15.8%			1
1.5	Muniac Str.	3,907	1.0%		173	100%	3,907	0.8%			Shikatehawk
1.6	River de Chute	2,026	0.5%		179	100%	2,026	0.4%			Big Presquile
1.7	Monquart Str. (inacc.- dam)		0.0%	5,110	191	100%		0.0%			1
1.8	Shikatehawk Str.	4,540	1.1%		201	100%	4,540	0.9%			1
1.9	Big Presquile Str.	1,887	0.5%		601	28%	6,810	1.4%	4,923		1
1.10	Little Presquile Str.	1,632	0.4%		144	100%	1,632	0.3%			Big Presquile
1.11	Mainstem-Hartland to Beechwood		0.0%		204	100%		0.0%			1
1.12	Becaguimec Str.	10,700	2.6%		527	100%	10,700	2.2%			1
1.13	Meduxnekeag R.	2,169	0.5%		1,327	18%	8,300	1.7%	6,131	4,022	1, 2
1.14	Eel R.	5,443	1.3%		586	100%	5,443	1.1%			Meduxnekeag
1.15	Shogomoc R.	2,250	0.6%		242	100%	2,250	0.5%			Meduxnekeag
1.16	Pokiok R.	2,124	0.5%		229	100%	2,124	0.4%			Meduxnekeag
1.17	Nackawic R. (40% inacc.-dam)	7,656	1.9%	5,104	478	100%	7,656	1.5%			1
1.18	Mactaquac R.	2,045	0.5%		220	100%	2,045	0.4%			Meduxnekeag
	Total Upriver of Mactaquac Dam	**144,316**	**35.7%**	**10,214**	16,630		215,186	43.3%	70,870	4,022	1
Saint John River, Downriver of Mactaquac Dam											
2	Keswick R.	10,100	2.5%		522	100%	10,100	2.0%			1
3	Nashwaaksis R.	2,570	0.6%		194	100%	2,570	0.5%			1
4	Nashwaak R.	56,920	14.1%		1,708	100%	56,920	11.4%			1
5	Oromocto R.	27,148	6.7%		2,026	100%	27,148	5.5%			Nerepis
6	Jemseg R.	63,298	15.6%		3,590	100%	63,298	12.7%			1
6.1	Portobello Cr. Gr. Lk	1,350	0.3%		78	100%	1,350	0.3%			1
6.2	Noonan Br., Gr. Lk	2,688	0.7%		155.1	100%	2,688	0.5%			Portobello
6.3	Burpee Mill Str., Gr. Lk	2,190	0.5%		99	100%	2,190	0.4%			1
6.4	Little R. Gr Lk	10,160	2.5%		432	100%	10,160	2.0%			1
6.5	Newcastle Cr., Gr. Lk	5,220	1.3%		227	100%	5,220	1.0%			1
6.6	Gaspereau R. Gr. Lk	18,240	4.5%		445	100%	18,240	3.7%			1
6.7	Salmon R. Gr. Lk	16,280	4.0%		1,420	100%	16,280	3.3%			1
6.8	Coal Cr., Gr. Lk.	3,720	0.9%		251	100%	3,720	0.7%			1
6.9	Cumberland Bay Gr. Lk	1,150	0.3%		95	100%	1,150	0.2%			1
6.10	Youngs Cove Gr. Lk.	2,300	0.6%		90	100%	2,300	0.5%			Cumberland

Location	Tributary / Sub-tributary	DU16 (CANADA ONLY) Area (100 m²) units ACC. Prod. (>0.12%)	% of Prod. Habitat DU 16	Area (100 m²) units INACC. Prod.	CANADA and U.S. WATERS Drainage Area (km²)	% Drainage Area in NB	Area (100 m²) units ACC. Prod. (>0.12%)	% of Prod. Habitat in Drainage	U.S.ONLY Est. Area (100 m²) units Prod.	Area (100 m²) units INACC. Prod.	Prod. Habitat Ref. or Proxy Riv.
7	Canaan R.	23,870	5.9%		2,168	100%	23,870	4.8%			1
8	Bellisle Cr.	3,900	1.0%		369	100%	3,900	0.8%			1
9	Nerepis R.	6,760	1.7%		504	100%	6,760	1.4%			1
10	Kennebecasis R.	20,690	5.1%		1,573	100%	20,690	4.2%			1
11	Hammond R.	16,620	4.1%		514	100%	16,620	3.3%			1
	Total Downriver of Mactaquac Dam	**231,876**	**57.3%**	**0**	12,969		231,875	46.6%		0	1
	Total Saint John River	**376,192**	**93.0%**	**10,214**	599		447,061	89.9%	70,870	4,022	
Outer Fundy complex rivers											
12	Musquash R. (innac- dam.)		0.0%	2,750	467	100%		0.0%			Lepreau
13	New R.	604	0.1%		152	100%	604	0.1%			
14	Pocologan R.	226	0.1%		57	100%	226	0.0%			5
15	Magaguadavic R.	5,630	1.4%		1,861	100%	5,630	1.1%			4
16	Digdeguash R.	4,220	1.0%		459	100%	4,220	0.8%			4
17	Bocabec R.	427	0.1%		108	100%	427	0.1%			
18	Waweig R.	556	0.1%		140	100%	556	0.1%			
19	Dennis Str.	537	0.1%		136	100%	537	0.1%			
20	St. Croix R.	16,183	4.0%		4,235	38%	38,039	7.6%	21,856		6, 7, 8, 9
	Total outer Fundy complex	**28,383**	**7.0%**	**2,750**	7,615		50,239	10.1%	21,856	0	
	TOTAL DESIGNATABLE UNIT	**404,575**	**100.0%**	**12,964**	37,214		497,301	100.0%	92,726	4,022	

Key:
References: 1-Marshall et al. 1997; 2-Baum 1982; 3-Anon. 1978a; 4-Anon.1978b; 5-Dalziel 1956; 6-Marshall and Cameron 1995; 7-Anon. 1988; 8-Fletcher and Meister 1982; 9-Havey 1963.

[a] The North Branch of the Meduxnekeag River is inaccessible past the two natural falls at Oakville, NB, near the US border. The majority of the inaccessible estimate presented is within US borders (Baum 1982).

[b] An impassable falls on the Dunbar Stream, approximately 0.8 km from the confluence with the Nashwaak River, is a natural barrier to salmon and offers another 1,486 unit of potential salmon rearing habitat migration.

[c] Reliable productive estimate for Lepreau River (Anon 1978a) used as proxy for Musquash River.

[d] Majority of habitat estimates are in International waters (29,097). The US section includes the habitat that solely lies in US waters (7,308) plus half the international estimate.

Table 9b: Estimates of accessible juvenile salmon habitat (total and productive) units (100 m²) and electrofishing results from surveys conducted in 2009. Number of sites, total habitat units surveyed, mean fry and parr (age-1 parr and older) densities per 100 m^2. Period (.) equals no data.

Location / Tributary / Sub-tributary		Productive Habitat Area (100 m² units)	No. sites	Surveyed Habitat Area (100 m² units)	Mean Density Fry	Parr	Total	Key	Survey Data[1]
Saint John River, Upriver of Mactaquac Dam									
1	Upriver of Mactaquac Dam								
1.1	Salmon R.	12,754	5	39	0.3	0.1	0.4		DFO
1.2	Mainstem-Aroostook to Grand Falls	5,400							
1.3	Aroostook R.	61,037							
1.4	Tobique R.	78,562	17	183	2.2	2.4	4.6		DFO, TSPA
1.5	Muniac Str.	3,907	3	23	1.1	1.1	2.2		DFO
1.6	River de Chute	2,026	3	23	0.0	0.0	0.0		DFO
1.7	Monquart Str.(inacc.- dam)	-	1	9	11.6	2.6	14.2		DFO
1.8	Shikatehawk Str.	4,540	5	72	21.1	4.2	25.3		DFO
1.9	Big Presquile Str.	6,810	3	26	3.2	0.3	3.5		DFO
1.10	Little Presquile Str.	1,632	2	19	11.1	0.0	11.1		DFO
1.11	Mainstem-Hartland to Beechwood	-							
1.12	Becaguimec Str.	10,700	7	72	1.7	1.3	3.1		DFO
1.13	Meduxnekeag R (inacc.-natural falls)	8,300	4	31	1.1	0.5	0.6		DFO
1.14	Eel R.	5,443	4	36	0.6	0.0	0.6		DFO
1.15	Shogomoc R.	2,250	2	16	1.9	0.0	1.9		DFO
1.16	Pokiok R.	2,124	3	24	0.0	0.4	0.4		DFO
1.17	Nackawic R. (inacc.-dam)	7,656	5	41	0.1	0.7	0.9		DFO
1.18	Mactaquac R.	2,045	1	8	0.0	0.0	0.0		DFO
	Stickney Bk.		1	7	0.0	2.0	2.0		DFO
	Bulls Cr.		1	7	0.0	0.0	0.0		DFO
	Gibson Cr.		2	16	0.8	0.6	1.4		DFO
	Longs Cr.		2	15	0.0	0.2	0.2		DFO
	Mill Str.		1	10	0.0	0.0	0.0		DFO
Saint John River, Downriver of Mactaquac Dam									
2	Keswick R.	10,100	4	43	14.8	3.1	17.8	.	DFO
3	Nashwaaksis R.	2,570	2	15	0.8	4.4	5.2	.	DFO
4	Nashwaak R. (inacc.-natural falls)	56,920	10	128	5.6	3.3	8.9	.	DFO
5	Oromocto R.	27,148	9	72	0.5	0.2	0.7		DFO (8), DND (1)
6	Jemseg R.								
6.1	Portobello Cr. Gr. Lk.	1,350							
6.2	Noonan Br., Gr. Lk.	2,688	1	8	0.0	0.0	0.0	.	DFO
6.3	Burpe Mill Str., Gr. Lk.	2,190	3	24	0.0	0.0	0.0	.	DFO
6.4	Little R. Gr Lk	10,160	3	23	0.4	0.1	0.5	.	DFO
6.5	Newcastle Cr., Gr. Lk.	5,220	2	18	0.4	0.2	0.6	.	DFO
6.6	Gaspereau R. Gr. Lk.	18,240	3	25	0.1	0.0	0.1	.	DFO
6.7	Salmon R. Gr. Lk.	16,280	4	34	0.7	0.5	1.2	.	DFO
6.8	Coal Cr., Gr. Lk.	3,720	3	26	0.8	0.9	1.8	.	DFO
6.9	Cumberland Bay Gr. Lk.	1,150	2	17	0.0	0.0	0.0	.	DFO
6.10	Youngs Cove Gr. Lk.	2,300	1	9	0.0	0.0	0.0	.	DFO
7	Canaan R.	23,870	16	28	0.6	10.4	11.0	.	Canaan Assoc.
8	Bellisle Cr.	3,900	2	17	1.0	0.7	1.7	.	
9	Nerepis R.	6,760	11	43	2.3	0.2	2.5	2	DND (8), DFO (3)
10	Kennebecasis R.	20,690	5	58	3.6	1.9	5.5	.	DFO
11	Hammond R.	16,620	12		0.0	8.0	8.0	.	HRAA
Outer Fundy rivers in DU16									
12	Musquash R. (innac- dam.)	-							
13	New R.	604	2	11	0.7	0.4	1.1	.	ASF (assist DFO)
14	Pocologan R.	226	1	4	2.8	1.4	4.2	.	ASF (assist DFO)
15	Magaguadavic R.	5,630	12	49	0.0	0.0	0.0	3	ASF
16	Digdeguash R.	4,220	3	15	1.8	0.2	2.0	.	ASF (assist DFO)
17	Bocabec R.	427							
18	Waweig R.	556	3	13	0.0	0.0	0.0	.	ASF (assist DFO)
19	Dennis Str.	537	3	11	2.2	2.4	4.6	.	ASF (assist DFO)
20	St. Croix R.	38,039						.	

Key: [1] DFO-Fisheries and Oceans, TSPA-Tobique Salmon Protective Assoc., DND-Dept. of National Defence, CRFGA-Canaan River Fish and Game Assoc., HRAA-Hammond River Angling Assoc., ASF-Atlantic Salmon Federation.
[2] Site breakdown DFO (3) and DND (8), fry parr breakdown for DND sites was estimated using data from DFO sites (91.2% fry).
[3] Mean density of hatchery origin (conservation or escapes) fry and parr was 21.4 fish per 100 m^2.

Table 10: Annual means (calculated using GLM) of fry (age-0), age-1, and age-2 and older parr Atlantic Salmon densities (number per 100 m²) in the Tobique River, upriver of Mactaquac Dam, estimated during electrofishing surveys between 1970 to 2012. No surveys in 1980, 1987, 1990, and 1991. Period (.) equals no data.

Year	No.	age-0 density LSMEAN	age-1 density LSMEAN	age-2 density LSMEAN
1970	12	10.93	0.14	1.11
1971	12	15.67	3.13	4.43
1972	10	16.13	0.79	2.47
1973	12	54.53	0.78	8.56
1974	12	15.40	4.45	2.60
1975	12	49.42	10.98	3.53
1976	12	89.68	8.34	6.14
1977	12	44.75	13.58	2.37
1978	12	69.48	9.39	3.39
1979	7	37.54	26.10	9.03
1980	0	.	.	.
1981	8	88.23	12.42	3.56
1982	12	44.90	16.88	0.94
1983	12	16.54	7.54	1.60
1984	11	29.67	4.62	1.49
1985	11	58.77	6.80	2.51
1986	11	21.37	15.56	1.65
1987	0	.	.	.
1988	4	93.30	6.91	1.69
1989	4	31.30	12.31	1.71
1990	0	.	.	.
1991	0	.	.	.
1992	7	11.11	7.27	2.10
1993	5	36.72	10.74	3.30
1994	4	28.81	7.25	1.33
1995	5	37.46	10.28	3.82
1996	12	6.08	4.98	1.51
1997	12	12.13	4.67	1.38
1998	12	10.93	8.25	0.94
1999	12	9.67	5.60	1.48
2000	12	13.27	3.79	0.61
2001	12	8.42	6.57	0.74
2002	12	4.61	2.98	0.39
2003	12	0.70	5.93	0.58
2004	12	5.90	2.28	0.84
2005	12	6.92	5.26	0.47
2006	12	3.99	3.73	0.23
2007	12	8.87	4.08	0.43
2008	12	1.91	2.76	0.43
2009	11	1.48	1.76	0.62
2010	12	12.81	1.90	0.63
2011	12	2.83	4.76	0.95
2012	12	4.90	5.54	1.21

Table 11: Number of wild and hatchery juvenile Atlantic Salmon collected during the spring and fall seasons for the captive-reared broodstock program at MBF, from the Tobique River and at Beechwood Dam. Period (.) equals no data.

Collection Year	Location	Pre-Smolt		Parr		Fry	Total
		Wild	Hatchery[a]	Wild	Hatchery[a]	Wild	
2001	Nictau	603	3	756	2	48	1,412
2001	Three Brooks	555	5	119	1	437	1,117
Smolt Class 2002		**1,158**	**8**	**875**	**3**	**485**	**2,529**
2002	Nictau	338	1	298	23	5	665
2002	Three Brooks	1,439	4	250	.	170	1,863
2002	Beechwood	832	1	5	.	.	838
Smolt Class 2003		**2,609**	**6**	**553**	**23**	**175**	**3,366**
2003	Nictau	1,005	57	726	22	.	1,810
2003	Three Brooks	563	26	221	.	.	810
Smolt Class 2004		**1,568**	**83**	**947**	**22**	**.**	**2,620**
2004	Nictau	536	.	367	1	.	904
2004	Three Brooks	221	.	61	.	.	282
2005	Three Brooks[b]	63	.	.	.	.	63
2005	Beechwood[b]	15	.	1	.	.	16
2005	Plaster Rock[b]	2	.	.	.	.	2
Smolt Class 2005		**837**	**.**	**428**	**1**	**.**	**1,267**
2005	Nictau	878	2	331	.	.	1,211
2005	Three Brooks	338	.	74	.	.	412
2006	Beechwood[b]	1,678	-		.	.	1,678
Smolt Class 2006		**2,894**	**2**	**405**	**-**	**.**	**3,301**
2006	Nictau	964	.	480	.	.	1,444
2006	Three Brooks	501	.	254	.	.	755
2007	Beechwood[b]	295	.		.	.	295
Smolt Class 2007		**1,760**	**-**	**734**	**-**	**.**	**2,494**
2007	Beechwood	524	.	3	.	.	527
2007	Nictau	539	.	240	.	.	779
2007	Three Brooks	450	.	110	.	.	560
2008	Beechwood[b]	45	.		.	.	45
Smolt Class 2008		**1,558**	**-**	**353**	**-**	**.**	**1,911**
2008	Nictau	415	.	512	.	.	927
2008	Three Brooks	883	.	185	.	.	1,068
2009	Three Brooks[b]	30	.	.	.	.	30
2009	Beechwood[b]	122	.	.	.	.	122
Smolt Class 2009		**1,450**	**-**	**697**	**-**	**.**	**2,147**
2009	Nictau	864	.	682	.	1	1,547
2009	Three Brooks	875	.	365	.	.	1,240
2009	Beechwood	18	.	.	.	.	18
2010	Three Brooks[b]	158	.	.	.	.	158
2010	Beechwood[b]	635	7	.	.	.	642
Smolt Class 2010		**2,550**	**7**	**1,047**	**-**	**1**	**3,605**
2010	Nictau	353	.	.	.	.	353
2010	Three Brooks	719	.	.	.	.	719
2010	Beechwood	-	.	.	.	.	0
2011	Three Brooks[b]	27	.	.	.	.	27
2011	Beechwood[b]	218	.	.	.	.	218
Smolt Class 2011		**1,317**	**-**	**-**	**-**	**-**	**1,317**
2011	Nictau	319	.	.	.	.	319
2011	Three Brooks	1,406	.	1	.	.	1,407
2011	Beechwood	63	.	.	.	.	63
2012	Three Brooks[b]	39	.	.	.	.	39
2012	Beechwood[b]	-	.	.	.	.	0
Smolt Class 2012		**1,827**	**-**	**1**	**-**	**-**	**1,828**
2012	Nictau	258	.	.	.	.	258
2012	Beechwood	-	.	.	.	.	0
2012	Three Brooks	892	.	.	.	.	892
Smolt Class 2013		**1,150**	**-**	**-**	**-**	**-**	**1,150**
Grand Total		**20,678**	**106**	**6,040**	**49**	**661**	**27,535**

Key: [a] Stocked previous year as fall fingerling. [b] Collected from spring projects at "smolt" stage.

Table 12a: Dates of operation and pre-smolt catches at RST(s) (Three Brooks location only), and data used to estimate emigrating pre-smolts on the Tobique River from 2001 to 2012. Period (.) equals no data.

Details	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Operation												
Start Date	24-Sep	02-Oct	29-Sep	24-Sep	29-Sep	25-Sep	1-Oct	1-Oct	29-Sep	28-Sep	4-Oct	01-Oct
End Date	13-Nov	16-Nov	09-Nov	14-Nov	21-Nov	1-Dec	12-Nov	16-Nov	1-Dec	19-Nov	21-Nov	27-Nov
Lost Fishing Days	0	8	9	3	5	6	4	4	1	2	7	7
# of RST's Fished	2	2	2	2	2	3	3	3	4	4	4	4
Estimated Efficiency	12.0%	.	.	.	.	8.3%	9.7%	7.4%	16.8%	12.7%	8.0%	10.2%
Catches												
Pre-smolt (Wild)	1,317	1,453	566	222	338	944	675	1,251	1,379	1,025	1,927	1,218
Pre-smolt (Hatchery)	64	101	34	26	47	638	99	102	133	223	171	68
Parr (Wild)	233	255	222	62	77	300	138	202	489	252	181	362
Parr (Hatchery)	11	6	1	9	7	38	13	5	360	26	10	13
Fry	957	941	76	86	130	168	291	20	188	1,056	36	140
Population Estimates												
Pre-smolt (Wild)												
Marked	1,496	.	.	.	.	558	21	386	505	310	565	331
Recap	189	.	.	.	.	68	24	32	85	41	52	36
Catch	1,319	.	.	.	.	1,510	774	1,353	1,512	1,248	2,098	1,286
Estimate	**[a]10,400**	**[b]5,740**	**[b]9,760**	**[b]7,050**	**[b]18,500**	**[c]11,560**	**[c]6,920**	**[c]16,770**	**[c]8,190**	**[c]8,075**	**[c]24,180**	**[c]11,930**
2.5th percentile	9,200	.	.	.	.	9,389	5,107	12,624	6,905	6,521	19,220	9,042
97.5th percentile	12,000	.	.	.	.	15,033	10,650	24,479	10,021	10,508	32,102	17,374
Pre-smolt (Hatchery)												
Marked	98	.	.	.	.	558	85	86	119	196	150	22
Recap	3	.	.	.	.	68	6	3	20	23	6	-
Catch	63	.	.	.	.	1,510	774	1,353	1,512	1,248	2,098	1,286
Estimate	**[a]2,100**	**[b]1,290**	**[b]904**	**[b]1,550**	**[b]3,700**	**[c]7,480**	**[c]1,020**	**[c]1,350**	**[c]790**	**[c]1,800**	**[c]2,145**	**[c]670**
2.5th percentile	1,100	.	.	.	.	6,076	753	1,016	666	1,454	1,705	508
97.5th percentile	14,100	.	.	.	.	9,727	1,570	1,971	967	2,342	2,848	976
Pre-smolt (Wild and Hatchery)												
Total estimates	.	.	.	.	.	**19,040**	**7,940**	**18,120**	**8,990**	**9,875**	**26,325**	**12,600**
2.5th percentile	.	.	.	.	.	15,465	5,860	13,640	7,580	7,975	20,925	9,550
97.5th percentile	.	.	.	.	.	24,760	12,220	26,450	11,000	2,850	34,950	18,350

Key:
[a] Wild and hatchery pre-smolt estimates calculated separately using the mark and recapture data by origin.
[b] Pre-smolt estimates are estimated from the ratio of fall pre-smolts in 2001, 2006 to the spring smolts in 2002, 2007.
[c] Wild and hatchery data (marked, recap, catch) combined and proportion of catches used to split estimate into wild and hatchery.

Table 12b: Dates of operation and smolt catches at RST(s) (Three Brooks location only), and data used to estimate emigrating smolts on the Tobique River from 2001 to 2012. Period (.) equals no data.

Details	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Operation												
Start Date	4-May	24-Apr	07-May	23-Apr	4-May	25-Apr	29-Apr	5-May	4-May	14-Apr	2-May	26-Apr
End Date	28-May	05-Jun	28-May	09-Jun	8-Jun	30-May	30-May	2-Jun	3-Jun	25-May	9-Jun	23-May
Lost Fishing Days	0	0	0	0	1	5	4	5	0	0	0	0
# of RST's Fished	2	3	2	2	1	2	2	2	3	4	4	4
Estimated Efficiency - recycled wild/hff	7.4%	5.2%	4.3%	6.2%	1.6%	6.6%	6.4%	1.8%	7.6%	8.7%	4.8%	5.3%
Estimated Efficiency - hatchery garment	.	4.1%	1.4%	.	1.1%	3.1%	1.6%	1.0%	0.4%	7.0%	3.4%	2.0%
Catches												
Smolt (Wild)	176	318	119	291	63	591	303	40	74	410	61	89
Smolt (Hatchery)	86	176	50	49	25	214	289	36	98	538	31	34
Population Estimates												
Smolt Wild/Hatchery												
Marked	149	422	139	275	62	784	575	55	132	762	62	76
Recap	11	22	6	17	1	52	37	1	10	66	3	4
Catch	262	494	169	340	88	805	592	76	172	948	92	123
Smolt (Hatchery) Garment Tag												
Marked	.	2,357	1,483	.	1,400	991	1,996	1,969	1,988	1,836	996	1,949
Recap	.	97	21	.	15	31	32	20	8	129	34	39
Catch	.	494	169	.	88	805	592	76	172	948	92	123
Smolt (Wild and Hatchery)												
Total estimates	**3,560**	**9,500**	**3,900**	**5,500**	**4,750**	**12,140**	**9,210**	**3,400**	**6,740**	**10,960**	**2,700**	**6,140**
2.5th percentile	2,280	6,770	2,250	3,785	3,640	9,520	7,040	2,910	5,520	8,880	1,000	4,940
97.5th percentile	7,960	15,870	12,755	9,875	7,120	16,200	13,270	4,330	8,840	14,240	12,400	8,400

Table 13: Start and finish dates for the operation of an adult salmon counting fence on the Nashwaak River, as well as the assessment technique used to estimate the total returns upriver of the fence site. The fence count as a proportion of the total estimated 1SW and MSW salmon and a mean (min., max.) fence capture efficiency. Period (.) equals no data.

						Fence count as proportion of total estimate	
Year	Start and Finish Date	Dates fence was not fishing 100%	Assessment Technique	Estimate up to	Year	1SW	MSW
1972	Aug. 18-Oct. 29	Sept. 4-6, Oct. 8-9, Oct. 25-28	.	.	.	.	.
1973	Jun. 10-Nov. 5	Jul. 5-11, Aug. 3-7	.	.	.	.	.
1975	Jun. 28-Oct. 29	Oct. 21-22	.	.	.	.	.
1993	Aug. 19-Oct. 12	.	Historical Run Timing	.	~~1993~~	~~0.00~~	~~0.28~~
1994	Jul 15-Oct. 25	.	Seining; Mark Recap	Oct. 25	1994	0.61	0.71
1995	Jul 12-Oct. 18	.	Historical Run Timing	.	~~1995~~	~~0.61~~	~~0.71~~
1996	Jun. 13-Oct. 18	Jul. 9-10, Jul. 14-31	Seining; Mark Recap	Oct. 18	1996	0.51	0.65
1997	Jun. 18-Nov. 2	.	Count; No Washouts	Nov. 1	~~1997~~	~~1.00~~	~~1.00~~
1998	Jun. 8-Oct. 27	Aug. 12-14, Oct. 2-5	Seining; Mark Recap	Oct. 27	1998	0.37	0.48
1999	Jun. 3-Oct. 13	Sept. 17-20, Sept. 23-28	Seining; Mark Recap	Oct. 13	1999	0.46	0.31
2000	Jun. 19-Oct. 26	Oct. 10-11	Seining; Mark Recap	Oct. 26	2000	0.84	0.84
2001	Jun. 21-Nov. 1	Aug. 3-17 [a]	Count; No Washouts	Nov. 1	~~2001~~	~~1.00~~	~~1.00~~
2002	Jun. 10-Oct. 28	.	Count; No Washouts	Oct. 28	~~2002~~	~~1.00~~	~~1.00~~
2003	Jun. 5-Oct. 26	Aug. 6-8, Oct. 15-17, Oct. 21-23	Seining; Mark Recap	Oct. 15 [b]	2003	0.63	0.75
2004	Jun. 3-Oct. 26	Aug. 31- Sept. 2, Sept. 9-12	Seining; Mark Recap	Oct. 26	2004	0.82	0.83
2005	Jun. 9-Oct. 7	Jun. 18-19, Aug. 30-Sept. 2, Sept.17-20 & 27-28	Seining; Mark Recap	Oct. 7	2005	0.58	0.59
2006	Jun. 1-Oct. 20	Jun. 4-5, Jun. 9-26, Jul. 5-6	Seining; Mark Recap	Oct. 20	2006	0.57	0.61
2007	May 30-Oct. 30	Oct. 13-14, Oct. 21 [c]	Seining; Mark Recap	Oct. 30	2007	0.47	0.95
2008	May 30-Oct. 22	Jun. 29-Jul. 4, Aug. 2-7, Aug. 9-14, Sept. 28-Oct. 10	Seining; Mark Recap	Sept. 28 [d]	2008	0.43	0.45
2009	May 29-Oct. 4	Jun. 12-15, Jun. 20-23, Jun. 29-Jul. 1, Jul. 4-6, Jul. 25-26, Jul. 30-31, Aug. 8, Sept. 29	Seining; Mark Recap	Oct. 4 [e]	2009	0.67	0.63
2010	May 28-Oct. 27	Jun. 5-8, Sept. 4, Oct. 1-3, Oct. 7-12, Oct. 16-19 [f]	Seining; Mark Recap	Oct. 15	2010	0.42	0.74
2011	Jun. 3-Oct. 16	Jun. 10-12,14,18-22, 25-27, Jul. 13,22-23,28, Jul.-31- Aug. 1, Aug. 23-24, Aug. 29-Sept. 19, Oct. 5	Seining; Mark Recap	Oct. 16	2011	0.40	0.40
2012	Jun. 1-Oct. 12	Jun. 26-Jul. 2,Sept. 30-Oct. 2, Oct. 7-8	Mean Fence Efficiency	Oct. 12	2012	.	.
~~years~~ not used calculations							
					Mean	0.56	0.64
					Min	0.37	0.31
					Max	0.84	0.95

Key:
[a] Fence was removed and base crib was raised 45 cm.
[b] Only two 1SW salmon were counted after Oct. 15, 2003.
[c] A couple holes large enough for a 1SW salmon to pass though were discovered in the fence around July 19, 2007.
[d] Only four 1SW and one MSW salmon were counted after Sept. 28, 2008
[e] Continued rainfall/highwater after Oct 4 did not allow for further operation. Fence was dismantled beginning on Oct. 13, 2009.
[f] Four to five holes large enough for a 1SW salmon to pass though were discovered in the fence after seining on Oct. 6, 2010.

Table 14: Estimated returns, escapement, eggs deposited and percent of Conservation Egg Requirement (CR) attained for the Nashwaak River, 1993-2012.

Year	Estimated Returns		Escapement		% of Requirement		Total Egg Deposition	
	1SW	MSW	1SW	MSW	1SW	MSW	Eggs Deposited	% CR
1993	954	555	866	555	42%	27%	3,947,841	31%
1994	661	388	610	349	30%	17%	3,264,340	26%
1995	940	436	940	436	46%	21%	4,222,157	33%
1996	1829	657	1804	641	88%	31%	6,202,877	48%
1997	370	366	364	362	18%	18%	2,888,199	23%
1998	1259	315	1238	309	61%	15%	3,917,071	31%
1999	665	275	658	269	32%	13%	2,468,024	19%
2000	509	192	489	189	24%	9%	1,886,981	15%
2001	244	272	224	266	11%	13%	2,034,132	16%
2002	343	79	320	69	16%	3%	725,198	6%
2003	297	113	280	109	14%	5%	950,300	7%
2004	590	207	569	201	28%	10%	2,116,130	17%
2005	731	162	712	155	35%	8%	2,007,482	16%
2006	716	195	681	186	33%	9%	2,044,636	16%
2007	469	106	442	98	22%	5%	1,166,495	9%
2008	1237	173	1217	168	60%	8%	2,931,693	23%
2009	297	336	274	328	13%	16%	1,780,154	14%
2010	2016	197	2008	195	98%	10%	3,942,271	31%
2011	1034	576	1033	575	51%	28%	4,739,127	37%
2012	29	61	29	61	1%	3%	322,084	3%
	Conservation Requirement (CR):				**2040**	**2040**	**12.8 Million Eggs**	

Table 15: Estimates of wild smolt emigration from upriver of Durham Bridge (and 2.5 and 97.5% percentiles), production per unit area of habitat (smolts/100 m^2) and the smolt-to-adult return rates for the Nashwaak River, 1998–2012. Period (.) equals no data.

Year	Wild Smolt Estimate			Production per unit area (smolts/100 m²)	Return Rate (%)	
	Mode	2.5 %	97.5%		1SW	2SW
1998	22,750	17,900	32,850	0.43	2.91	0.67
1999	28,500	25,300	33,200	0.54	1.79	0.84
2000	15,800	13,400	19,700	0.30	1.53	0.28
2001	11,000	8,100	17,400	0.21	3.11	0.90
2002	15,000	12,300	19,000	0.28	1.91	1.26
2003	9,000	6,800	13,200	0.17	6.38	1.58
2004	13,600	10,060	20,800	0.26	5.13	1.28
2005	5,200	3,200	12,600	0.10	12.73	1.52
2006	25,400	21,950	30,100	0.48	1.81	0.62
2007	21,550	16,675	30,175	0.41	5.63	1.26
2008	7,300	5,500	11,200	0.14	3.86	2.05
2009	15,900	12,150	22,850	0.30	12.41	3.31
2010	12,500	9,940	16,740	0.24	7.86	0.35
2011	8,750	7,130	11,300	0.17	0.33	.
2012	11,060	8,030	17,745	0.21	.	.

Table 16: Annual mean density (calculated using GLM) of fry (age-0), age-1, and age-2 and older parr (number per 100 m²) on the Nashwaak River, downriver of Mactaquac Dam, estimated during electrofishing surveys between 1970 to 2012. No survey took place in 1980. Period (.) equals no data.

Year	No.	age-0 density LSMEAN	age- 1density LSMEAN	age-2 density LSMEAN
1970	3	23.6	3.8	7.5
1971	7	58.4	7.4	7.9
1972	7	28.1	2.5	15.8
1973	7	32.7	0.1	12.4
1974	7	68.9	2.3	9.1
1975	7	63.2	15.1	11.8
1976	7	42.1	10.9	2.9
1977	7	28.6	12.4	2.6
1978	7	55.5	7.7	3.7
1979	5	64.4	15.8	4.8
1980	0	.	.	.
1981	6	59.2	15.3	4.4
1982	7	41.9	10.5	3.2
1983	7	22.9	7.0	2.9
1984	7	38.4	5.6	1.7
1985	7	40.3	6.3	2.5
1986	7	42.1	7.9	2.2
1987	7	59.6	11.2	0.8
1988	7	52.3	9.5	0.7
1989	7	47.7	9.0	1.6
1990	7	38.2	9.1	0.9
1991	7	32.6	9.0	1.1
1992	7	29.1	13.8	0.8
1993	7	14.0	6.5	1.4
1994	7	4.6	3.1	0.6
1995	7	11.6	8.1	1.5
1996	7	9.8	3.9	0.7
1997	7	15.2	5.4	0.8
1998	7	3.4	4.3	0.7
1999	7	8.7	4.1	1.3
2000	7	14.9	4.6	0.1
2001	7	12.1	11.1	1.5
2002	7	17.6	6.2	1.3
2003	7	4.1	4.7	0.7
2004	7	4.2	2.4	0.5
2005	7	6.1	4.6	0.5
2006	6	5.4	3.3	0.5
2007	7	4.7	3.4	0.5
2008	7	5.0	5.3	0.9
2009	7	5.2	3.1	0.7
2010	7	14.5	4.9	0.8
2011	6	1.8	3.8	0.0
2012	7	12.9	2.5	1.5

Table 17: Total 1SW and MSW returns to the rivers of DU 16 (OBoF population) from 1993 to 2012.

Part 1: 1SW Returns.

Year	Nashwaak	Saint John River Downriver	Saint John River Upriver	Mag + St. C	Other Fundy rivers	DU 16
1993	954	3,719	4,369	120	169	8,258
1994	661	2,577	3,534	116	164	6,275
1995	940	3,665	5,079	63	89	8,833
1996	1,829	7,131	6,723	71	100	13,954
1997	370	1,442	3,255	68	96	4,794
1998	1,250	4,873	4,982	60	85	9,940
1999	665	2,593	3,257	27	38	5,888
2000	510	1,988	3,068	28	40	5,096
2001	244	951	1,700	21	30	2,681
2002	343	1,337	2,358	21	30	3,725
2003	297	1,158	1,302	16	23	2,482
2004	590	2,300	1,487	8	11	3,798
2005	731	2,850	1,159	11	16	4,024
2006	716	2,791	1,333	25	35	4,160
2007	469	1,828	903	4	6	2,737
2008	1,237	4,823	1,801	4	6	6,629
2009	297	1,158	613	3	4	1,775
2010	2,016	7,860	2,394	12	17	10,271
2011	1,034	4,031	1,019	8	11	5,061
2012	29	113	81	0	0	194

Part 2: MSW Returns.

Year	Nashwaak	Saint John River Downriver	Saint John River Upriver	Mag + St. C	Other Fundy rivers	DU 16	TOTAL (1SW + MSW) Mature Individuals
1993	555	2,164	3,383	221	312	5,859	14,117
1994	388	1,513	2,347	98	138	3,998	10,273
1995	436	1,700	2,253	63	89	4,042	12,874
1996	657	2,561	3,311	130	184	6,056	20,010
1997	366	1,427	1,971	34	48	3,446	8,239
1998	315	1,228	967	12	17	2,212	12,152
1999	275	1,072	1,804	10	14	2,890	8,778
2000	190	741	544	6	8	1,293	6,389
2001	272	1,060	1,206	16	23	2,289	4,970
2002	79	308	376	6	8	692	4,417
2003	113	441	751	5	7	1,199	3,681
2004	207	807	712	4	6	1,525	5,323
2005	162	632	350	4	6	987	5,012
2006	195	760	347	6	8	1,116	5,275
2007	106	413	336	0	0	749	3,486
2008	173	674	281	0	0	955	7,585
2009	336	1,310	558	3	4	1,872	3,647
2010	197	768	460	0	0	1,228	11,499
2011	576	2,246	678	11	16	2,939	8,001
2012	61	238	132	1	1	371	565

Note 1: Assessed portion of the Nashwaak represents 0.2565 (0.285*0.9) of downriver habitat (Table 9; Jones et al. 2010). Nashwaak returns are included in the Downriver SJR totals.
Note 2: Magaguadavic and St. Croix rivers represent 0.7082 of the outer Fundy complex river habitat (Table 9a; Jones et al. 2010). The St. Croix and Magaguadavic returns are included in the other Fundy rivers totals.

Table 18: Conservation Requirement for the complex of rivers found within the DU 16 (OBoF population). Period (.) equals no data.

				Recent Bio characteristics			Egg Target Met by		
DU	**Complex of Rivers within DU**	**Rearing Units (100 m^2)**	**Egg Requirement (240 eggs/unit)**	**Eggs per Female 1SW**	**Eggs per Female MSW**	**Historical Prop. Eggs from MSW**	**Number of 1SW Salmon**	**Number of MSW Salmon**	**Total**
16	DU - Accessible Productive Habit – Canadian – **Long-term Recovery Target**								
	Saint John River - Upriver of Mactaquac	144,316	34,600,000	326	6,445	0.8799	12,750	4,720	17,470
	Saint John River - Downriver of Mactaquac	231,875	55,700,000	1,403	5,840	0.6160	15,240	5,870	21,110
	Outer Fundy complex	28,384	6,800,000	931	5,734	0.7601	1,750	900	2,650
	Recovery Target - Abundance	**404,574**	**97,100,000**	.	.	.	**29,740**	**11,490**	**41,230**
16	DU - Accessible Productive Habit – Canadian – **Short-term Recovery Target**								
	Saint John River - Upriver of Mactaquac								
	Tobique	78,562	18,900,000	326	6,445	0.8799	6,970	2,580	9,550
	Shikatehawk	4,540	1,100,000	326	6,445	0.8799	410	150	560
	Becaguimec	10,700	2,600,000	326	6,445	0.8799	960	350	1,310
		93,802	**22,600,000**	.	.	.	**8,340**	**3,080**	**11,420**
	Saint John River - Downriver of Mactaquac								
	Keswick	10,100	2,400,000	1,403	5,840	0.6160	660	250	910
	Nashwaak	56,920	13,700,000	1,403	5,840	0.6160	3,750	1,440	5,190
	Canaan	23,870	5,700,000	1,403	5,840	0.6160	1,560	600	2,160
	Kennebecasis	20,690	5,000,000	1,403	5,840	0.6160	1,370	530	1,900
	Hammond	16,620	4,000,000	1,403	5,840	0.6160	1,090	420	1,510
		128,200	**30,800,000**	.	.	.	**8,430**	**3,240**	**11,670**
	Outer Fundy complex								
	Digdeguash	4,220	1,000,000	931	5,734	0.7601	260	130	390
		4,220	**1,000,000**	**931**	**5,734**	**1**	**260**	**130**	**390**
	Recovery Target - Abundance	**226,222**	**54,400,000**	**931**	**5,734**	**1**	**17,030**	**6,450**	**23,480**

FIGURES

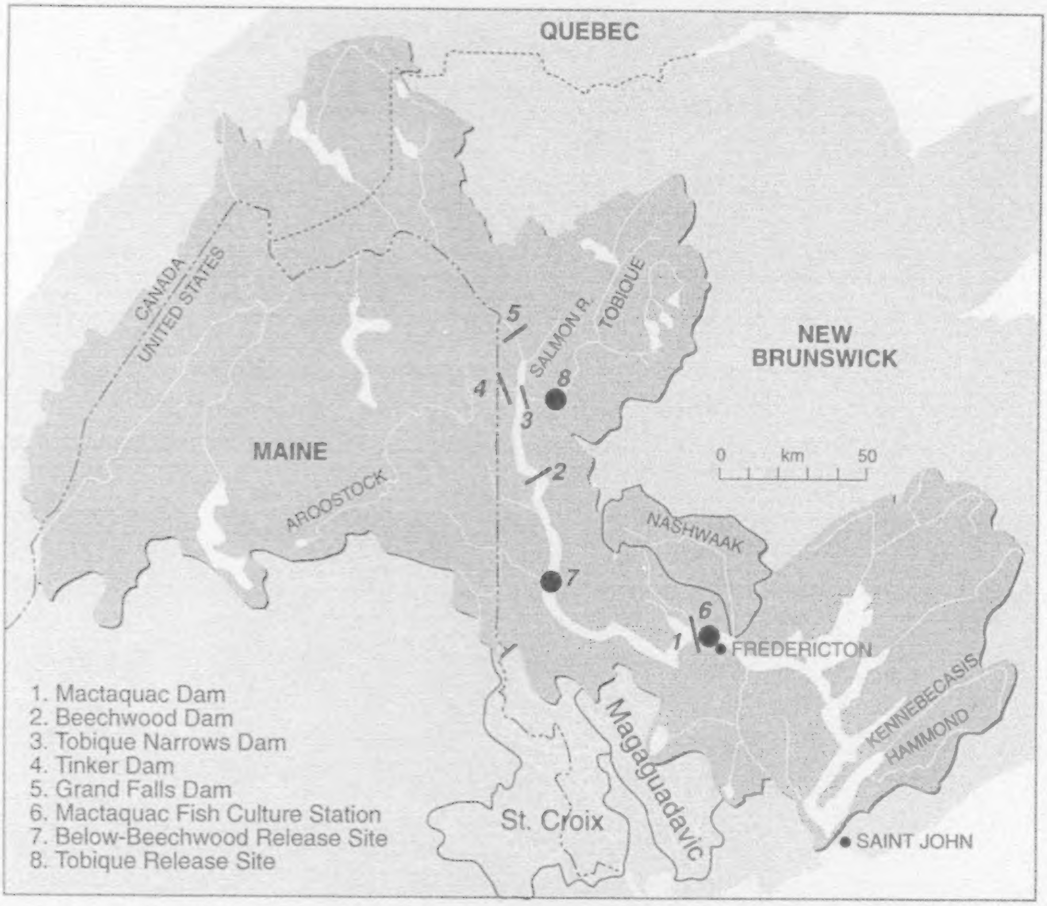


Figure 1: Map of the Magaguadavic, St. Croix and Saint John rivers' drainages including: Tobique and Nashwaak rivers and other major tributaries, dams, and principal release sites for Atlantic Salmon upriver of Mactaquac Dam. Fish trapping locations on the Tobique and Nashwaak drainages are shown in Fig. 8 and Fig. 13. Note that the Mactaquac Fish Culture Station is now referred to as the Mactaquac Biodiversity Facility or MBF.

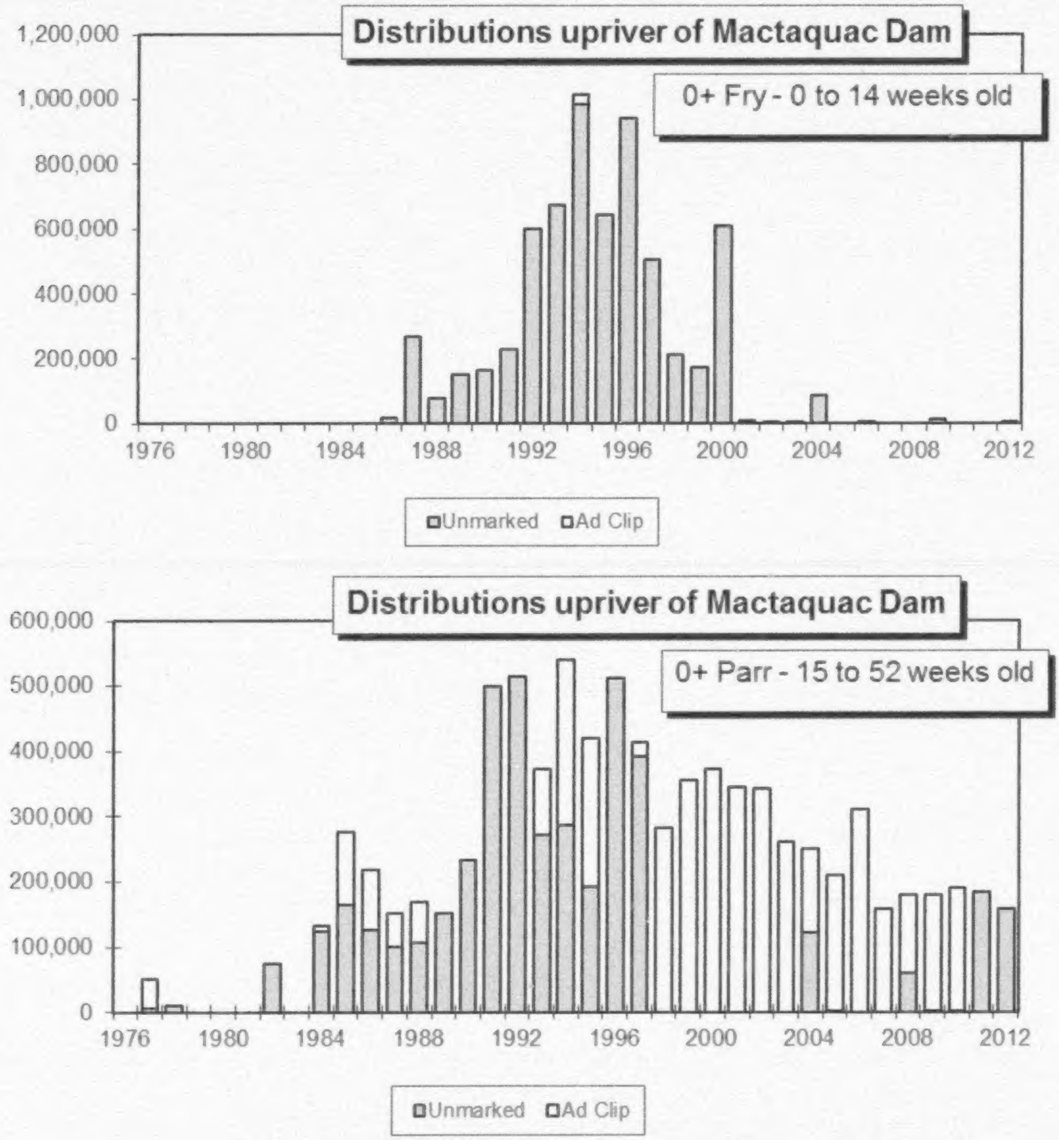
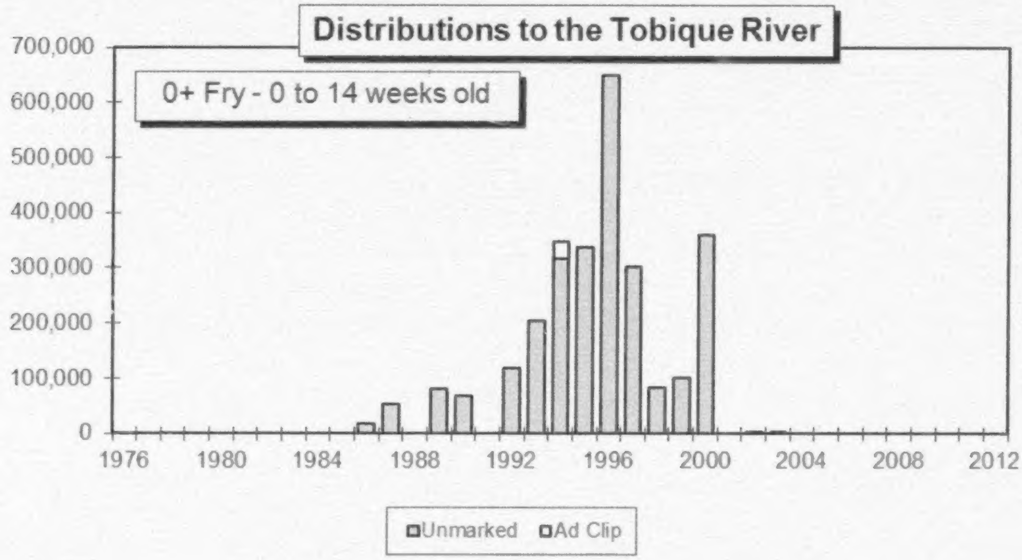


Figure 2a: Number of juvenile salmon less than 52 weeks old (excludes age-1 smolts) released or distributed to tributaries upriver of Mactaquac Dam on the Saint John River, 1976-2012.



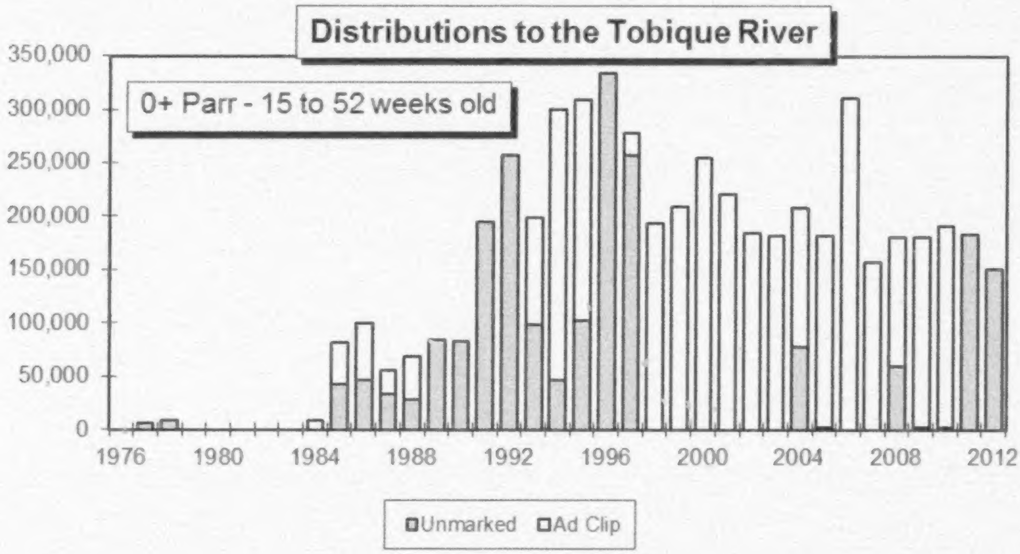


Figure 2b: Number of juvenile salmon less than 52 weeks old (excludes age-1 smolts) released or distributed to the Tobique River, 1976-2012.

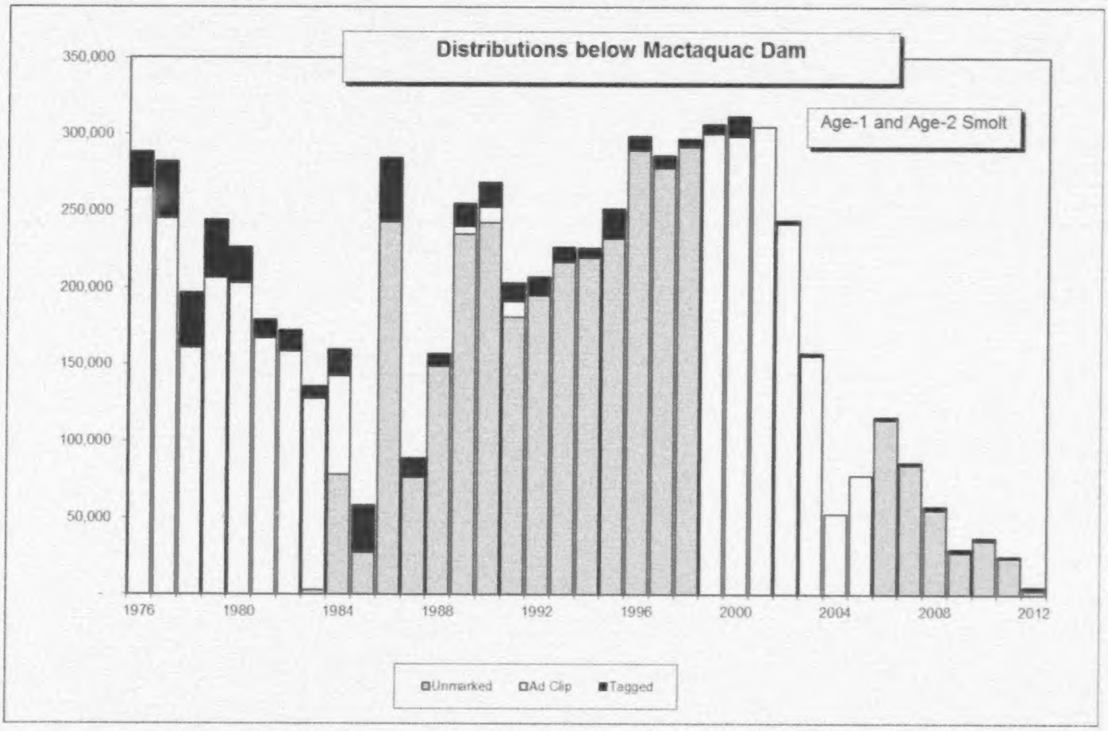
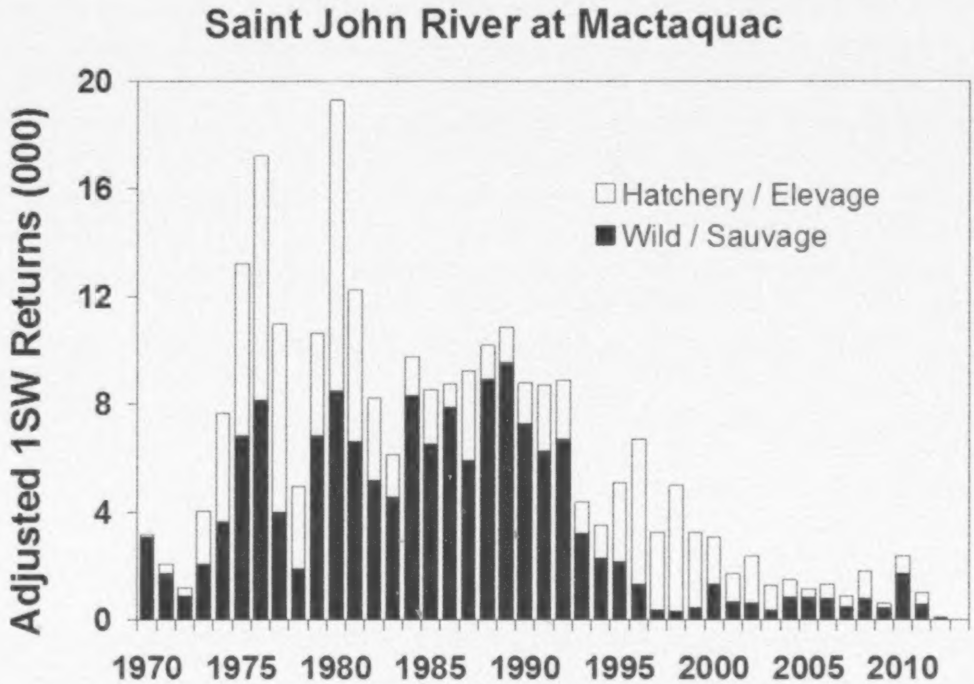


Figure 2c: Number of smolts (includes both age-1 and age-2 fish) released via the migration channel downriver of Mactaquac Dam on the Saint John River, 1976-2012.



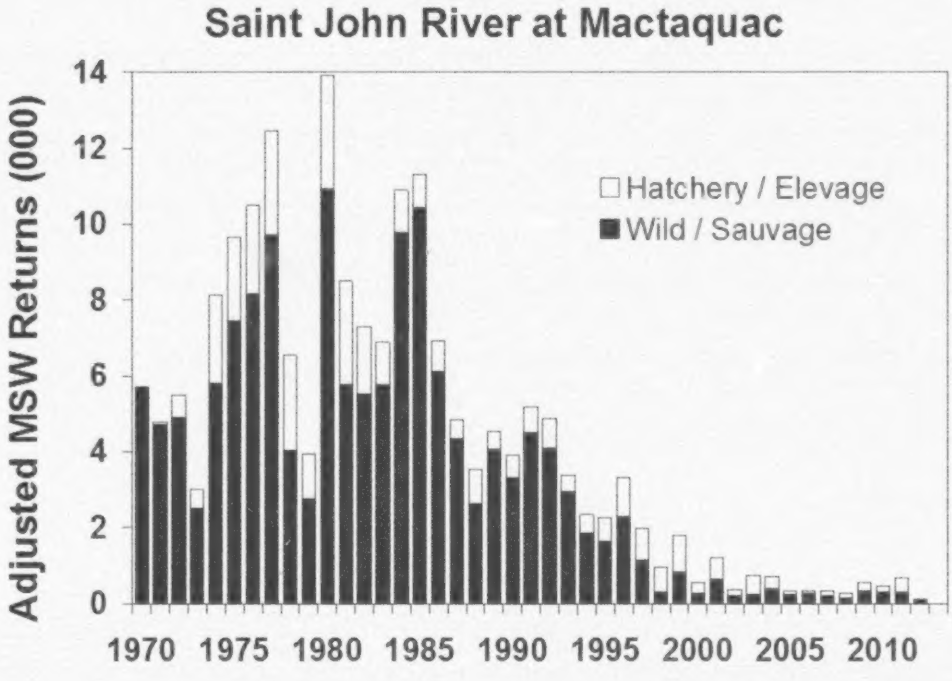


Figure 3: Estimated total adjusted returns of wild and hatchery 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, 1970-2012. The 'wild-origin' 1SW (since 2008) and MSW (since 2009) returns are progeny from sea-run and captive-reared spawners (releases began in 2004).

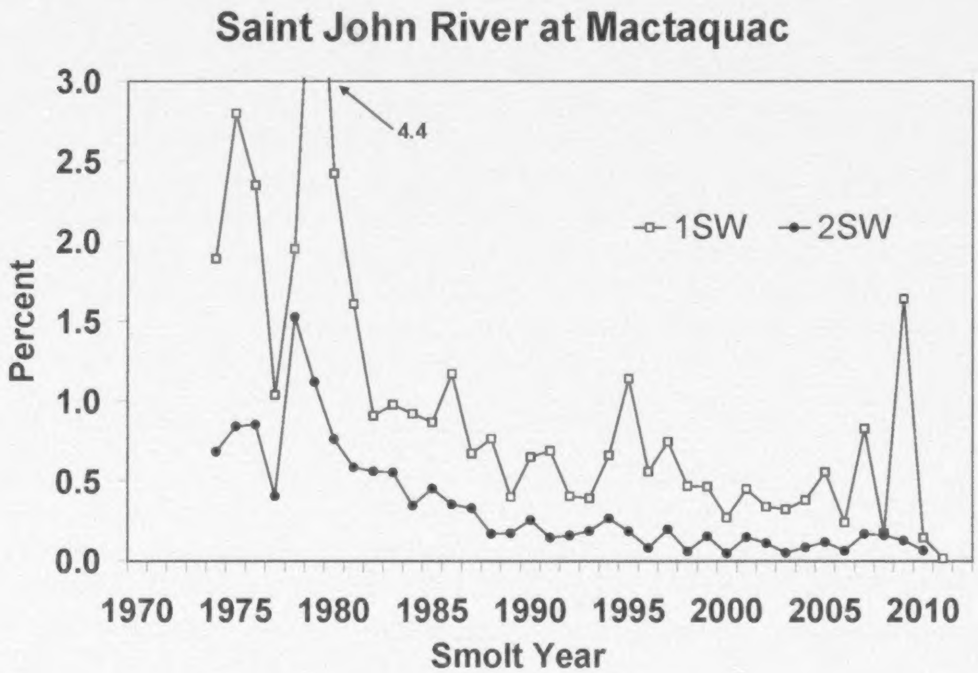


Figure 4: Return rates of hatchery reared smolts to virgin 1SW and virgin 2SW salmon destined for Mactaquac Dam on the Saint John River by smolt year, 1974–2007. The 2006 and 2007 smolt classes were from captive-reared broodstock originating in the Tobique River.

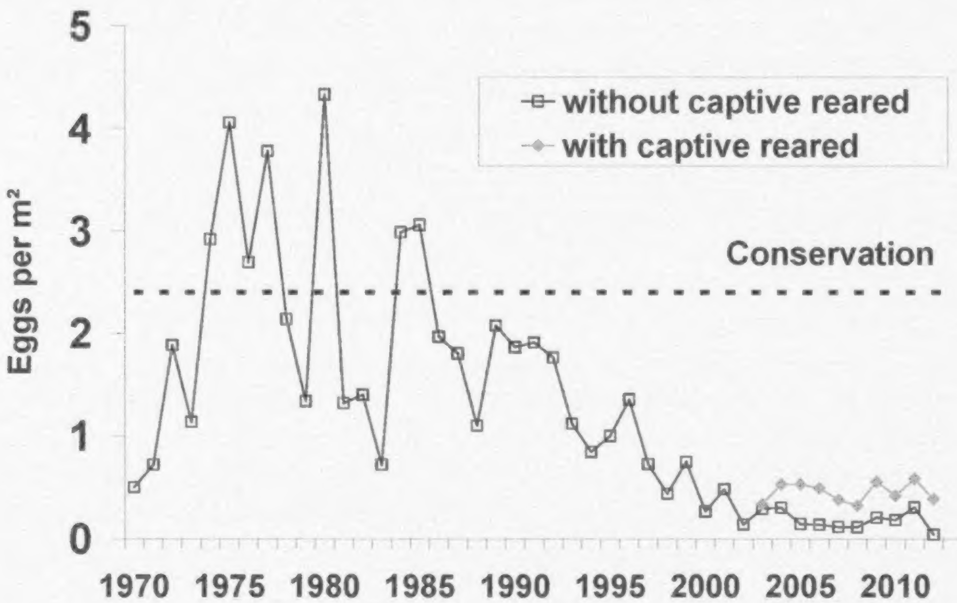


Figure 5: Estimated egg deposition upriver of Mactaquac Dam on the Saint John River, 1970-2012.

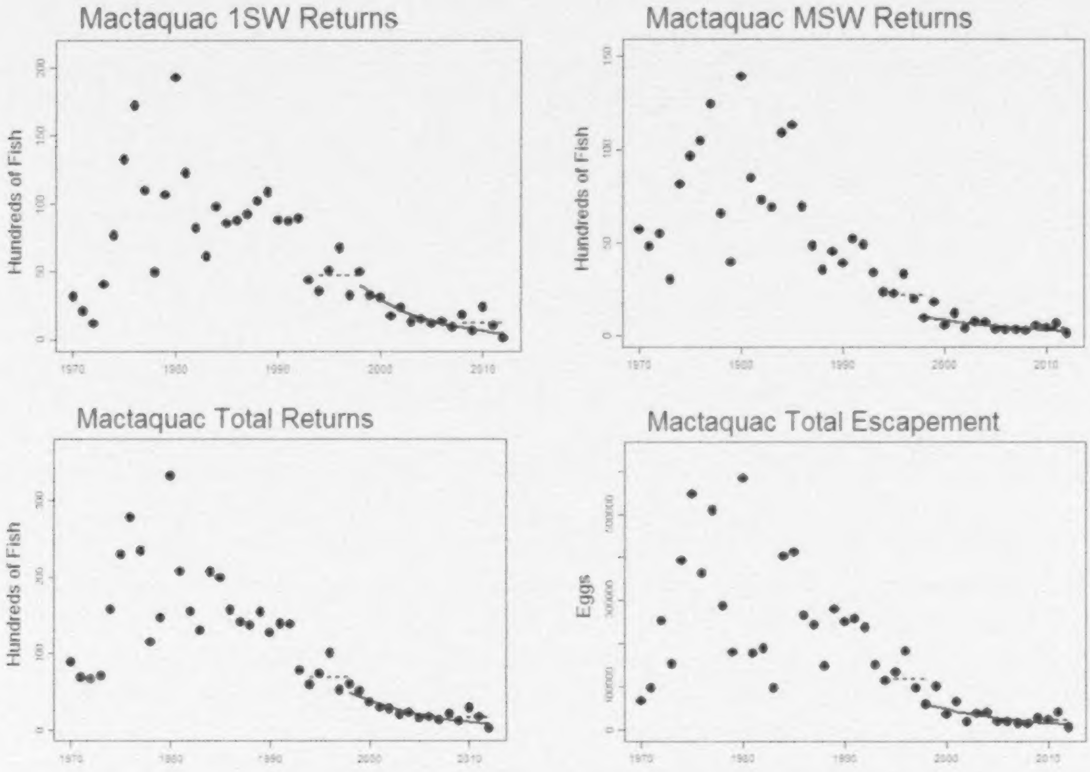
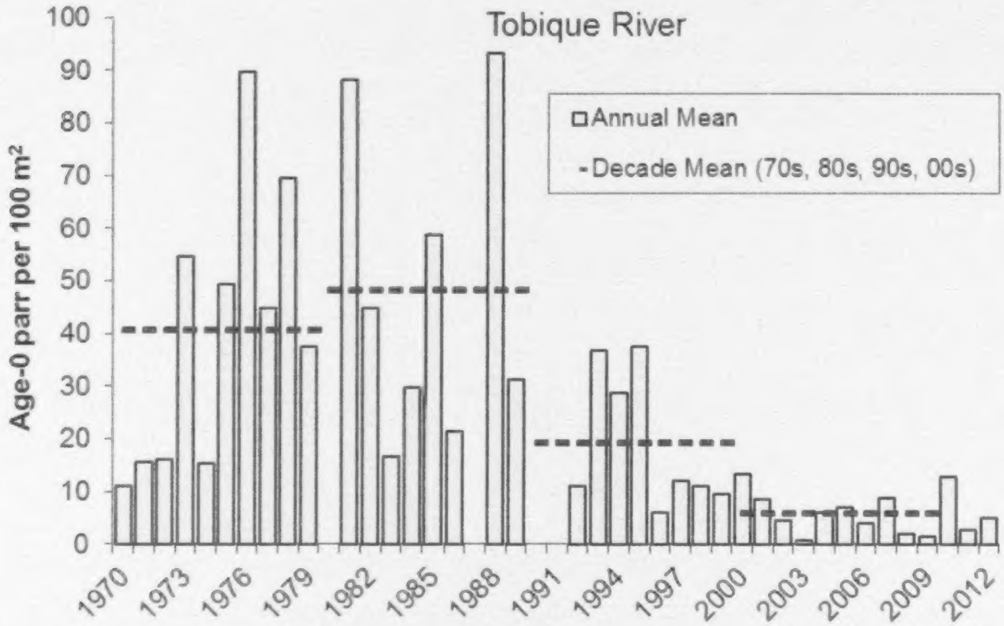


Figure 6: Trends in abundance of adult Atlantic Salmon in the Saint John River, upriver of Mactaquac Dam, during the last 15 years. The solid line is the predicted abundance from a log-linear model fit by least squares. The dashed lines show the 5-year mean abundance for two time periods ending in 1998 and in 2012. The points are the observed data. Model coefficients are provided in Table 8.



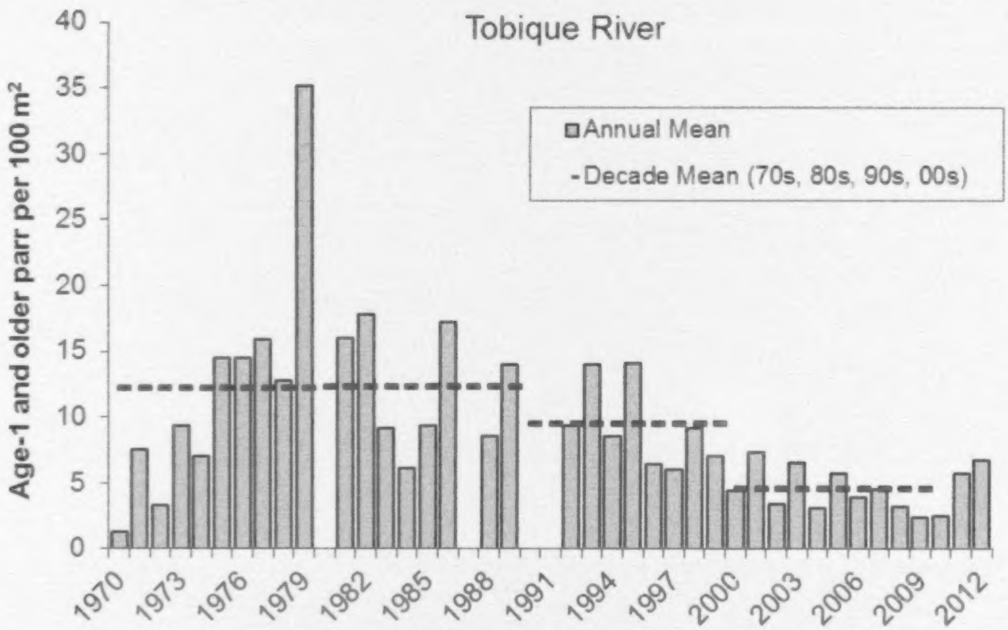
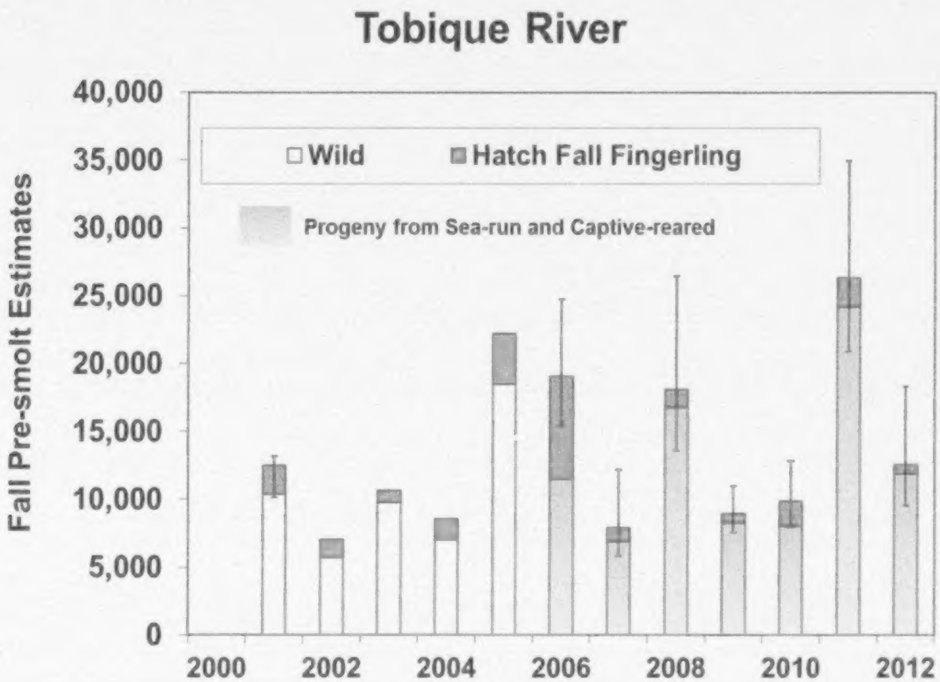


Figure 7: Annual mean densities of age-0 (fry) (upper panel) and age-1 and older parr (lower panel) from electrofishing sites on the Tobique River from 1970 to 2012. Dashed lines represent 10-year mean values for each decade (1970s, 1980s, 1990s, 2000s). No electrofishing sites were surveyed in 1980, 1987, 1990 and 1991.

Figure 8: Map of Tobique River showing the location of the RSTs (circles), release sites for smolts (squares) and adults (diamonds), the temperature recorder (star), the trapnet (star), the half mile fish protection barrier (circle) and river gauging station (star) sites.



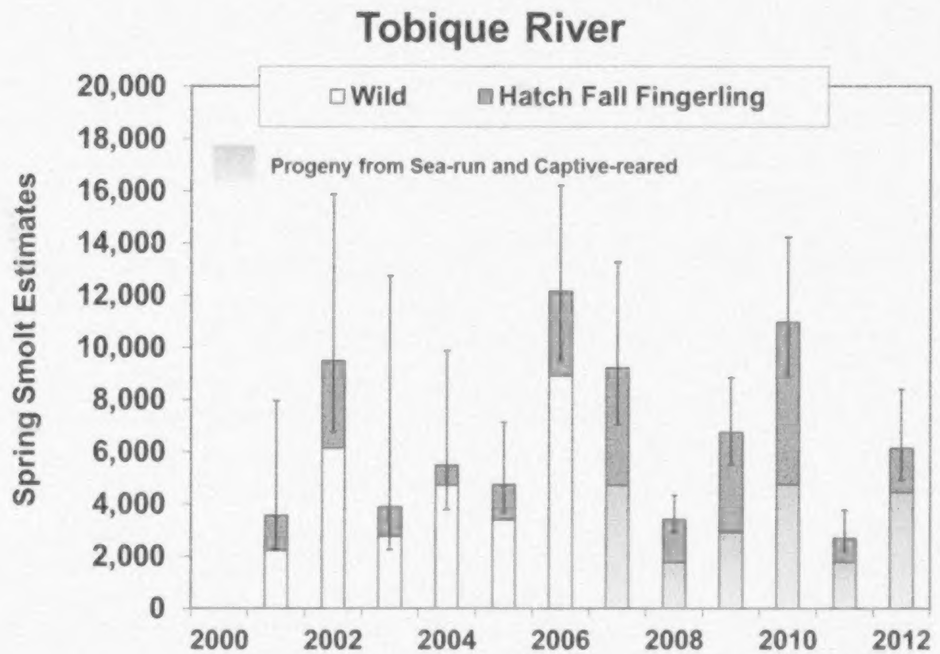


Figure 9: Estimated number (and 2.5 and 97.5 percentiles) of wild (or sea-run adults), hatchery (released as fall fingerlings) and sea-run adults/captive reared adults fall pre-smolt (upper) and spring smolts (lower) emigrating from the Tobique River, 2001 to 2012.

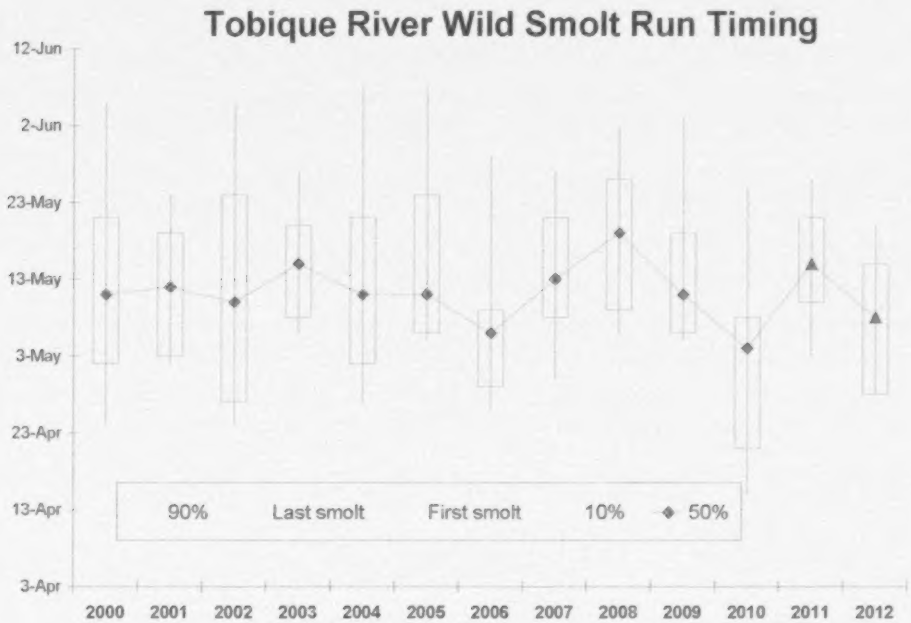


Figure 10: Distribution of wild smolt RST captures on the Tobique River (Odell; 2000 and Three Brooks; 2001-2012) by date and year; showing the first and last smolts captured, as well as the 10%, 50% and 90% cumulative proportion of catch from 2000 to 2012.

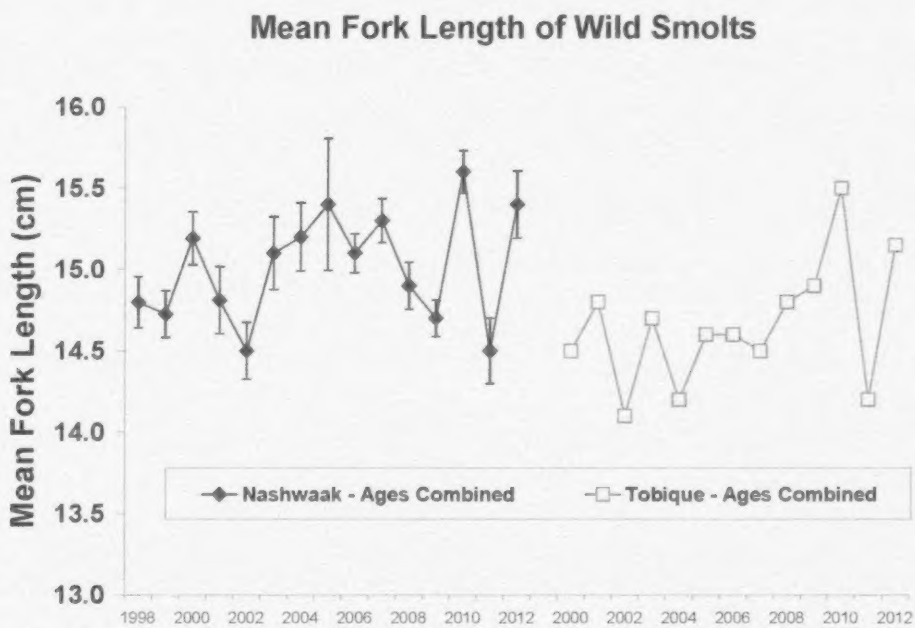


Figure 11: Mean fork length (+/- 2 times standard error) for wild smolts sampled during assessment projects on the Nashwaak (1998-2012) and Tobique (2000-2012) rivers.

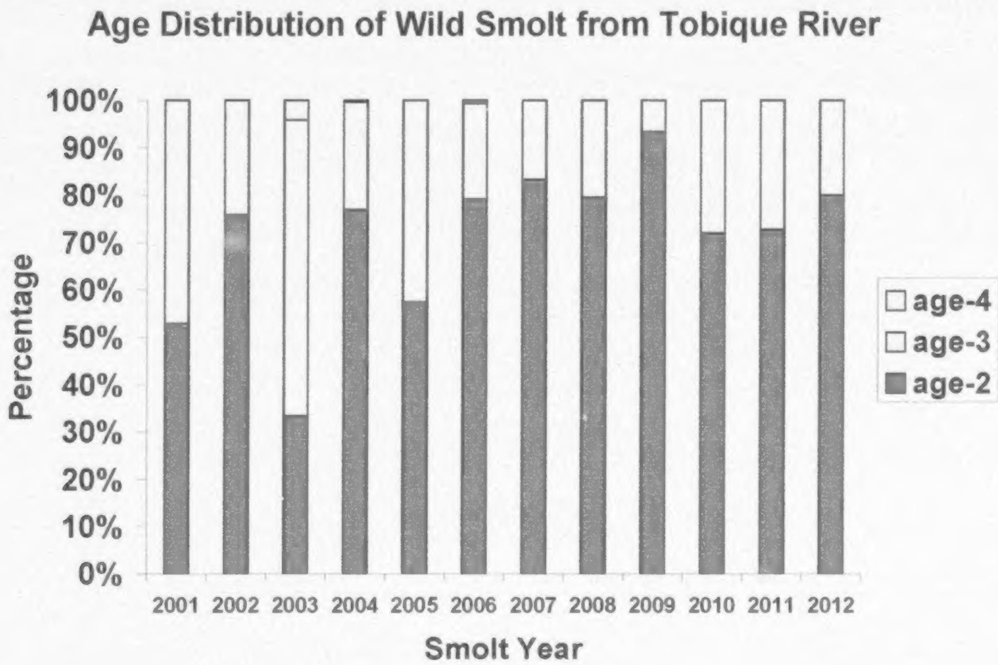


Figure 12: Percentages of age-2, age-3 and age-4 wild smolts emigrating from the Tobique River from 2001 to 2012.

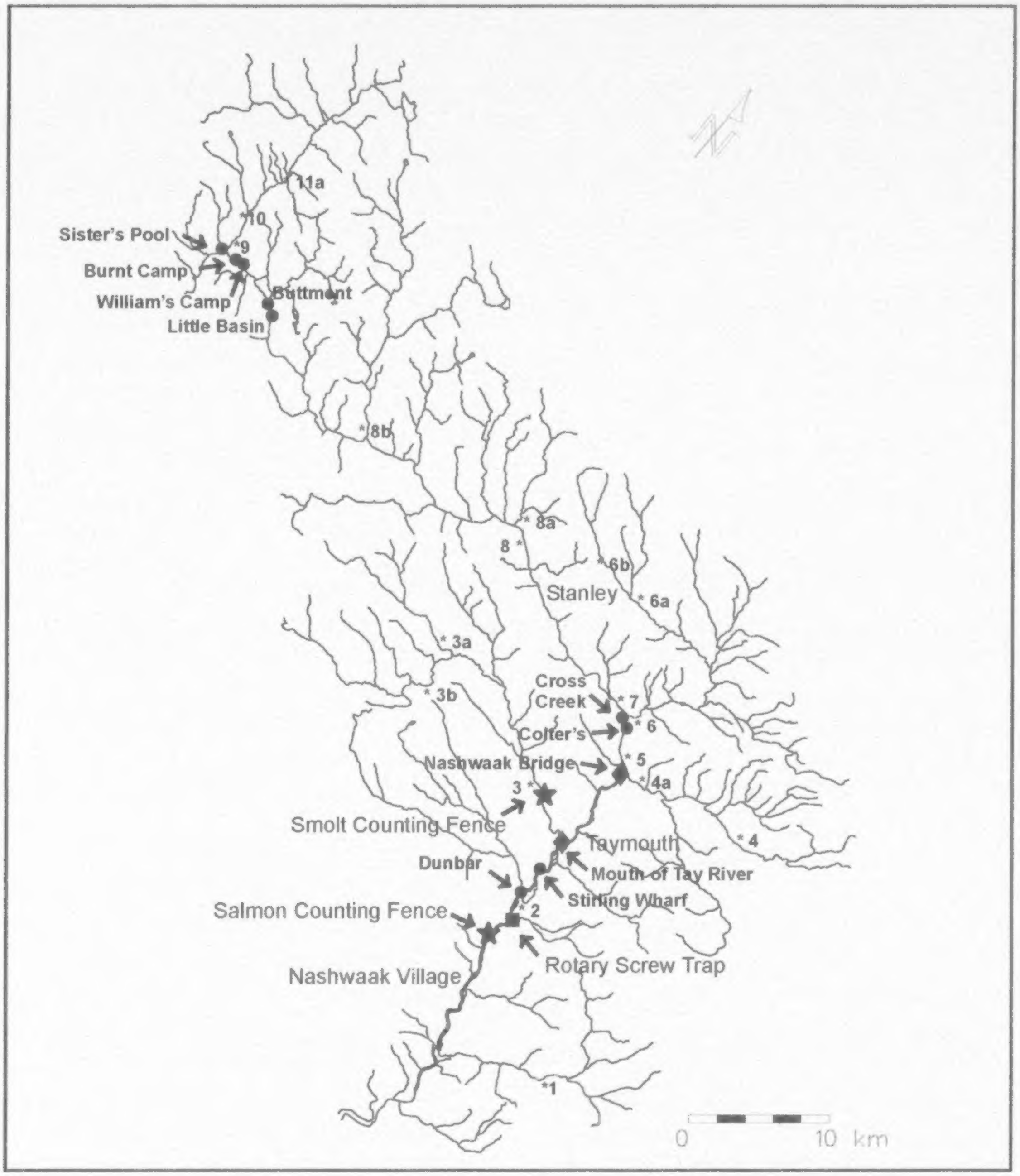


Figure 13: Map of the Nashwaak River, indicating the adult counting fence site (star), RST site (square), smolt fence (star), holding pools seined in adult recap activities (circles), and electrofishing sites (*). Historical index sites used in Table 16 are 1, 2, 3, 5, 8, 9, and 10.

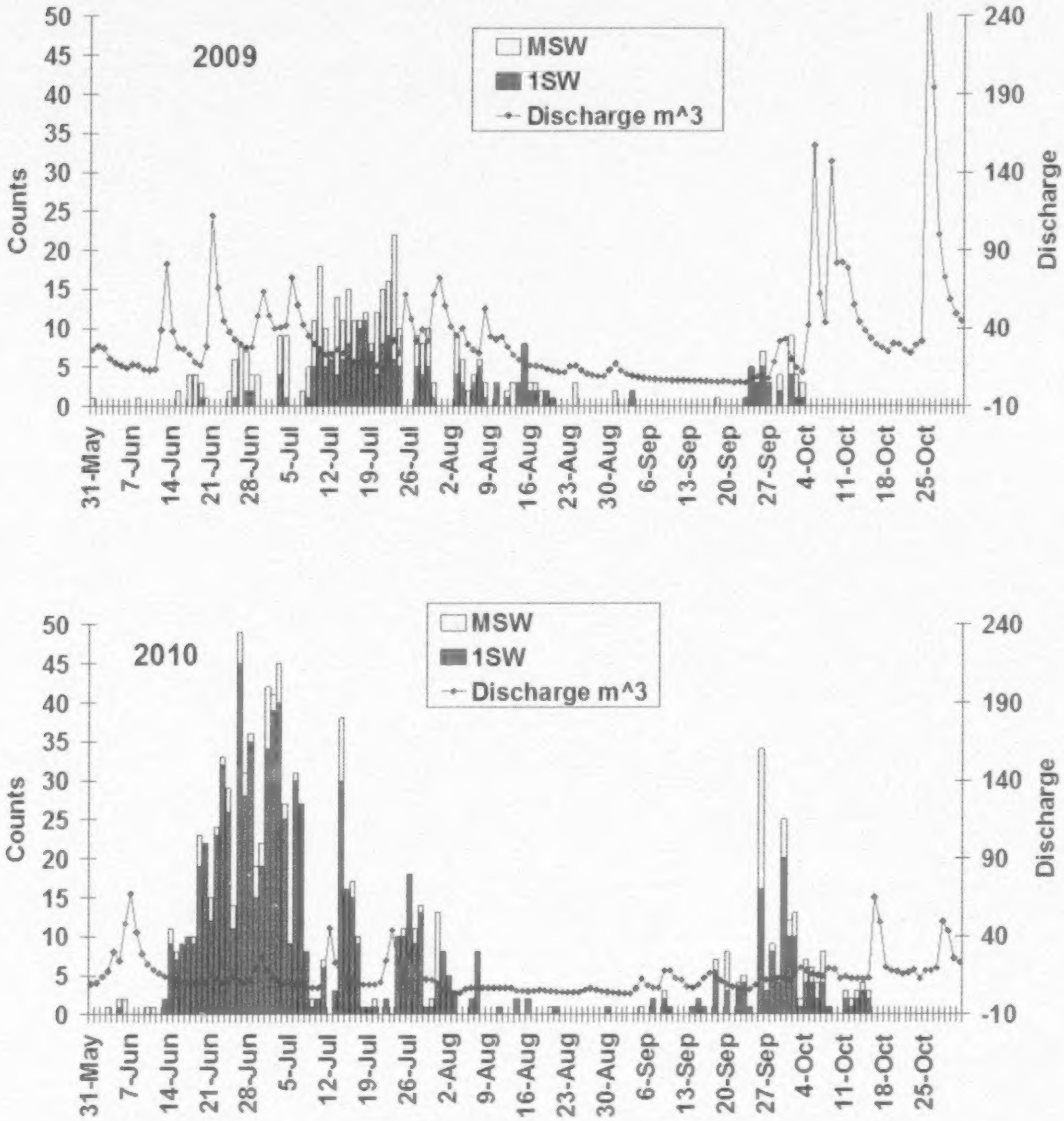
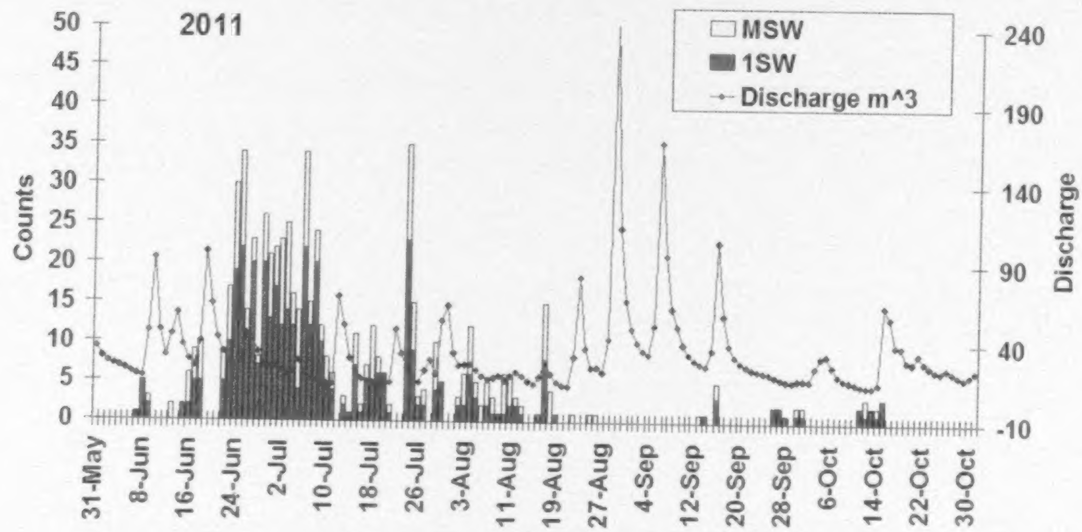


Figure 14a: Average daily discharge (m³/sec) at Durham Bridge and adjusted fence counts of 1SW and MSW salmon on the Nashwaak River, 2009–2010.



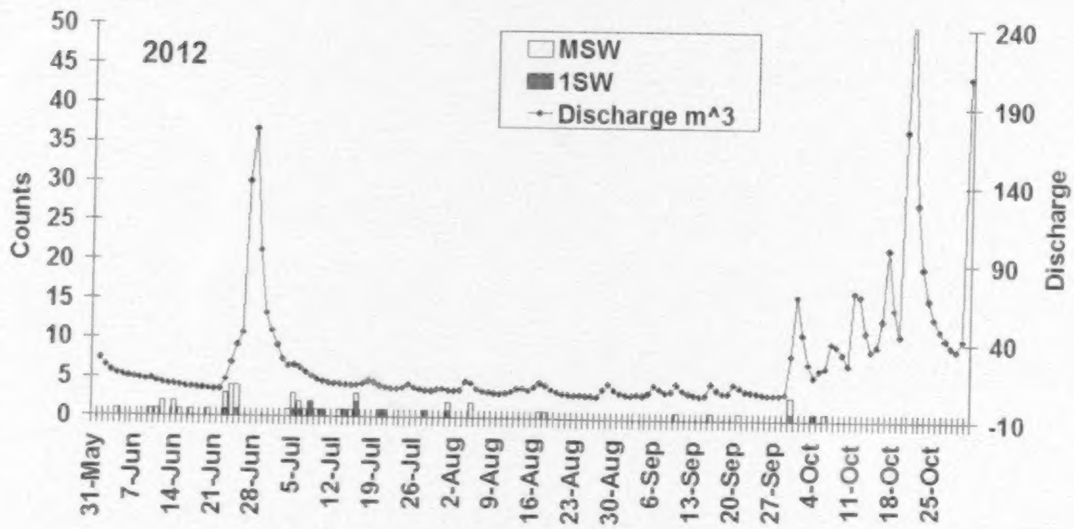
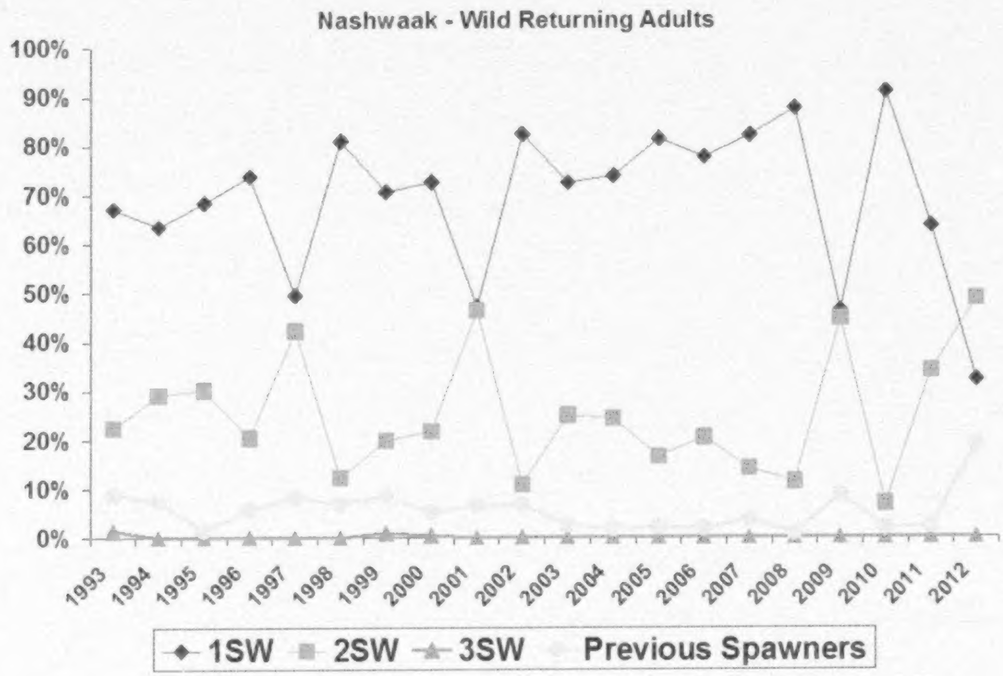


Figure 14b: Average daily discharge (m^3/sec) at Durham Bridge and adjusted fence counts of 1SW and MSW salmon on the Nashwaak River, 2011-2012.



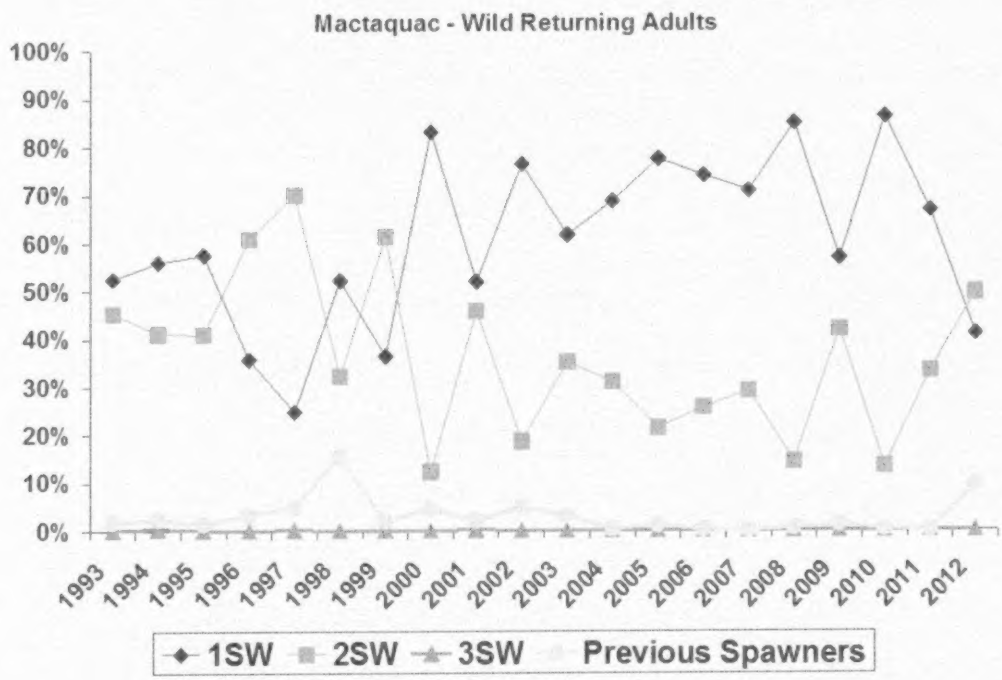


Figure 15: The percentages of wild virgin 1SW, 2SW, 3SW and previous spawning (repeat spawning) Atlantic Salmon in the total returns to the Nashwaak River and to Mactaquac, 1993-2012.

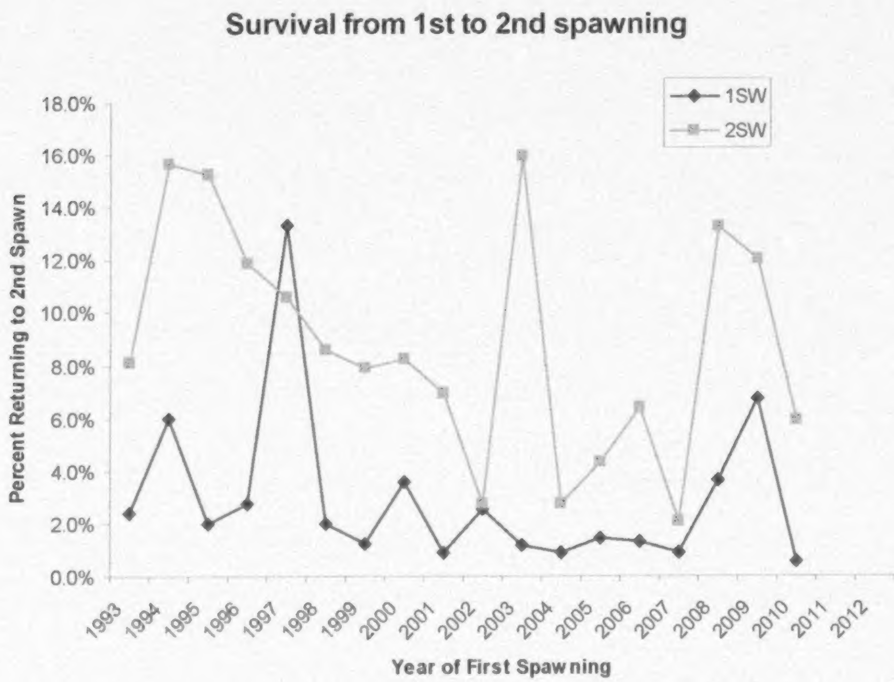
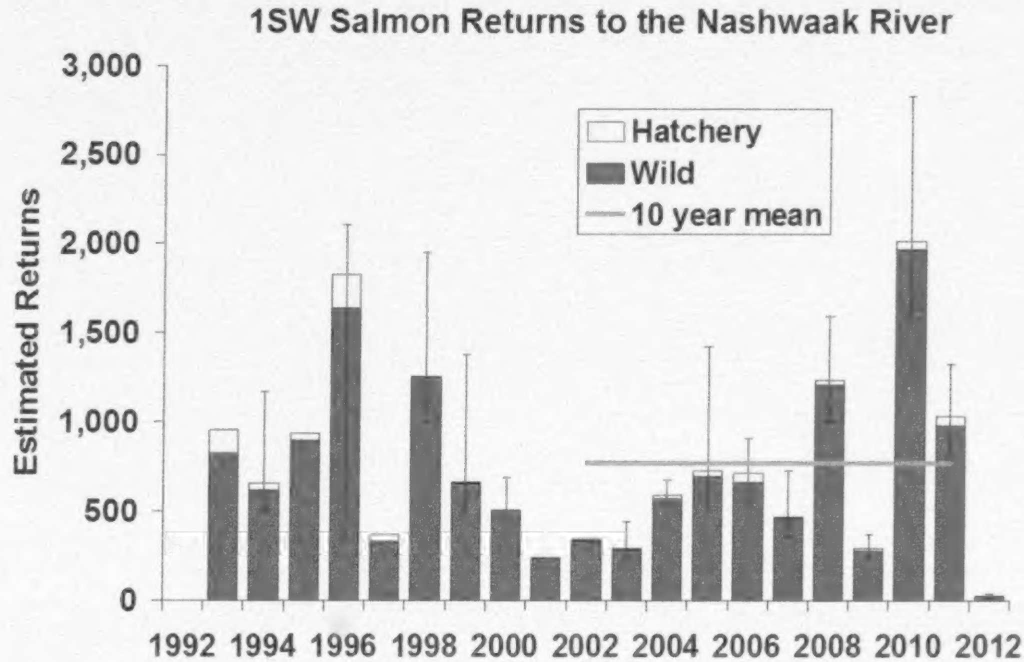


Figure 16: Percentage of maiden 1SW and 2SW salmon surviving to spawn as a consecutive (1 year later) or alternate (2 years later) repeat spawners on the Nashwaak River, 1993- 2010.



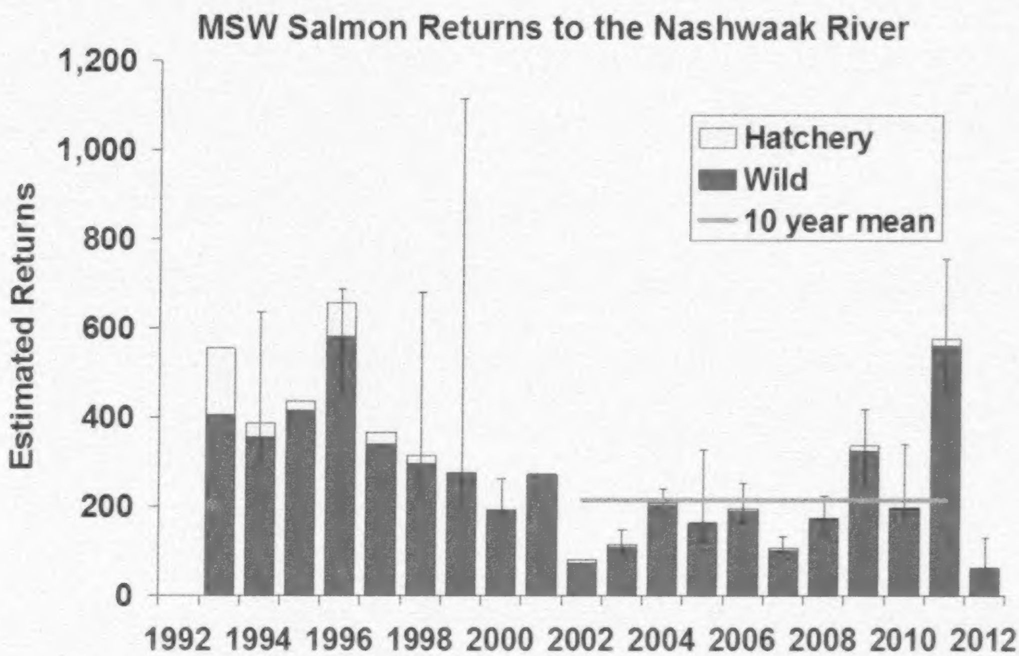


Figure 17: Estimated wild and hatchery 1SW and MSW salmon returns (and 2.5 and 97.5 percentiles) to the Nashwaak River, 1993-2012.

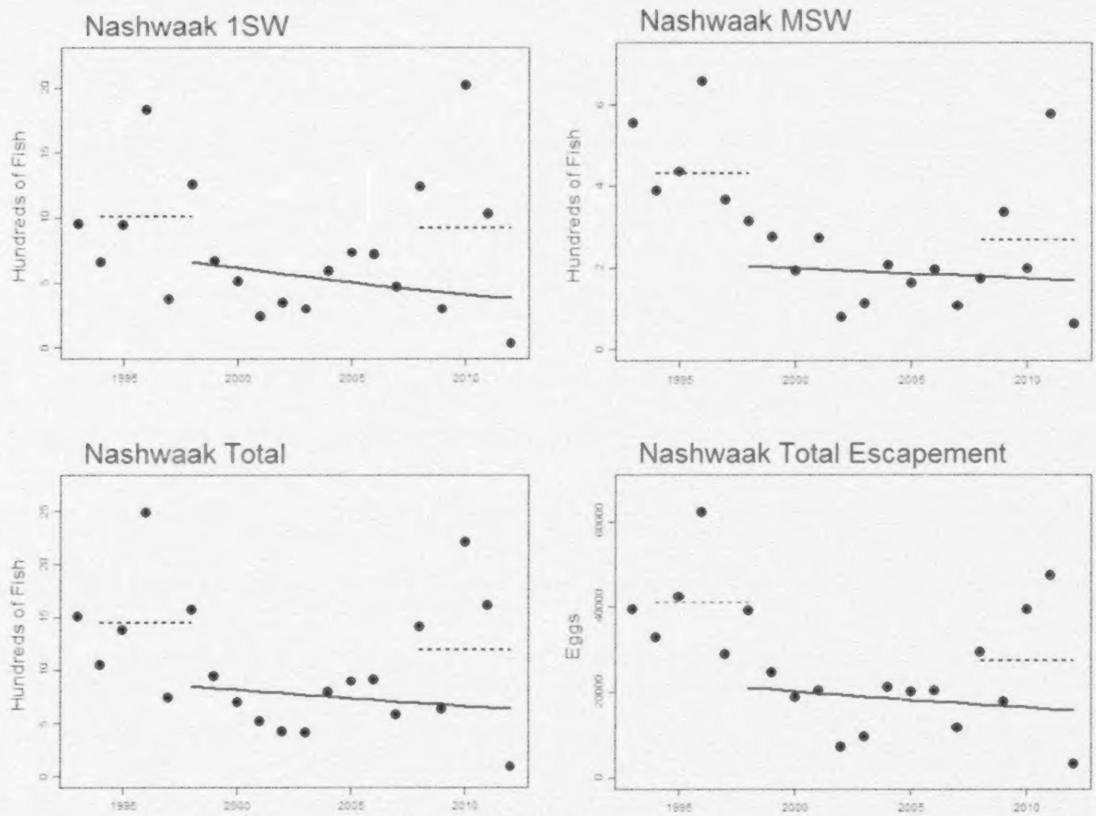


Figure 18: Trends in abundance of Atlantic Salmon returns in the Nashwaak River during the last 15 years. The solid line is the predicted abundance from a log-linear model fit by least squares over a 15-year time period. The dashed lines show the 5-year mean abundance for two time periods ending in 1998 and 2012. The points are the observed data. Model coefficients are provided in Table 8.

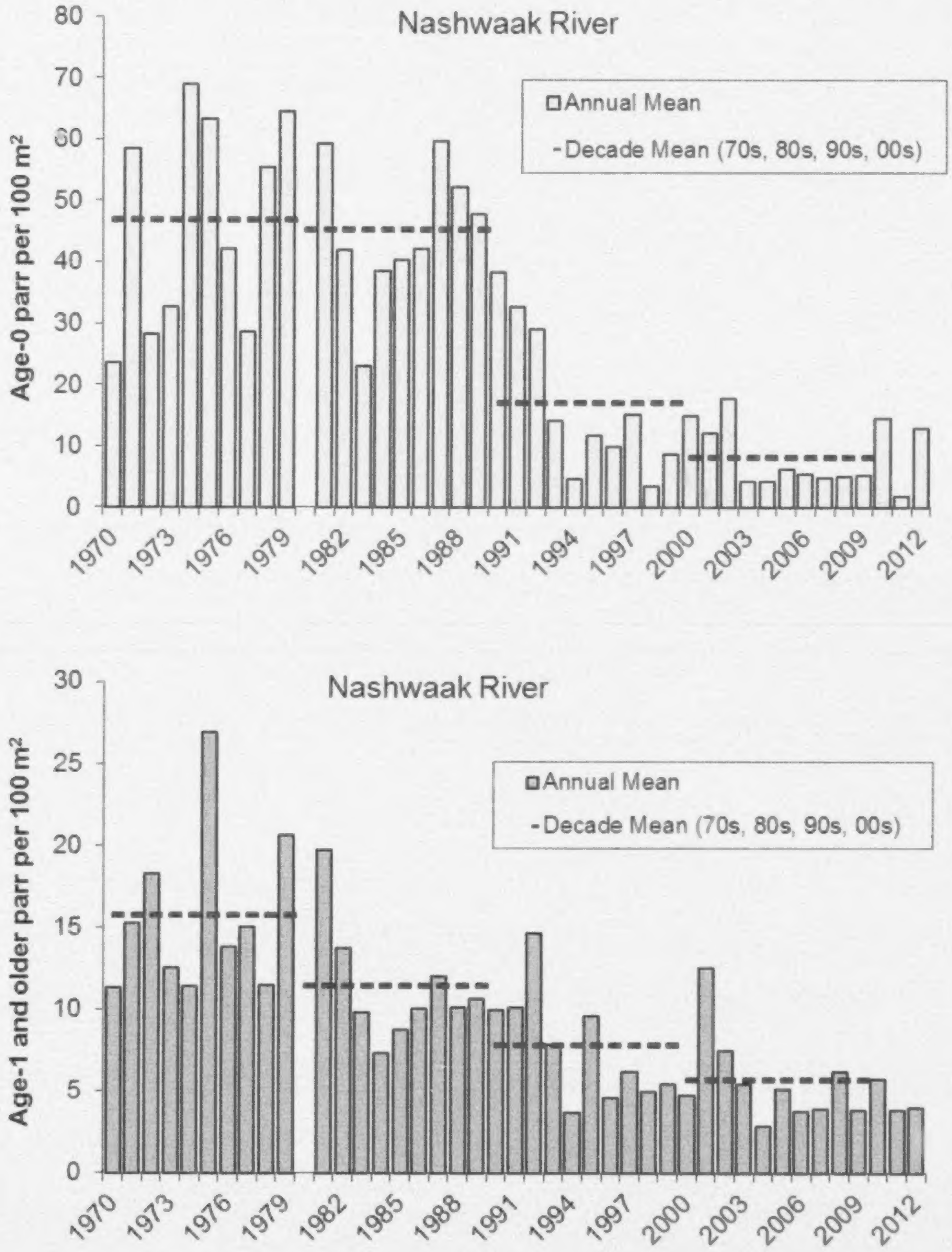


Figure 19: Annual mean densities of age-0 (fry) (upper panel) and age-1 and older parr (lower panel) from electrofishing sites on the Nashwaak River from 1970 to 2012. Dashed lines represent 10-year mean values for each decade (1970s, 1980s, 1990s, 2000s). No electrofishing surveys were conducted in 1983.

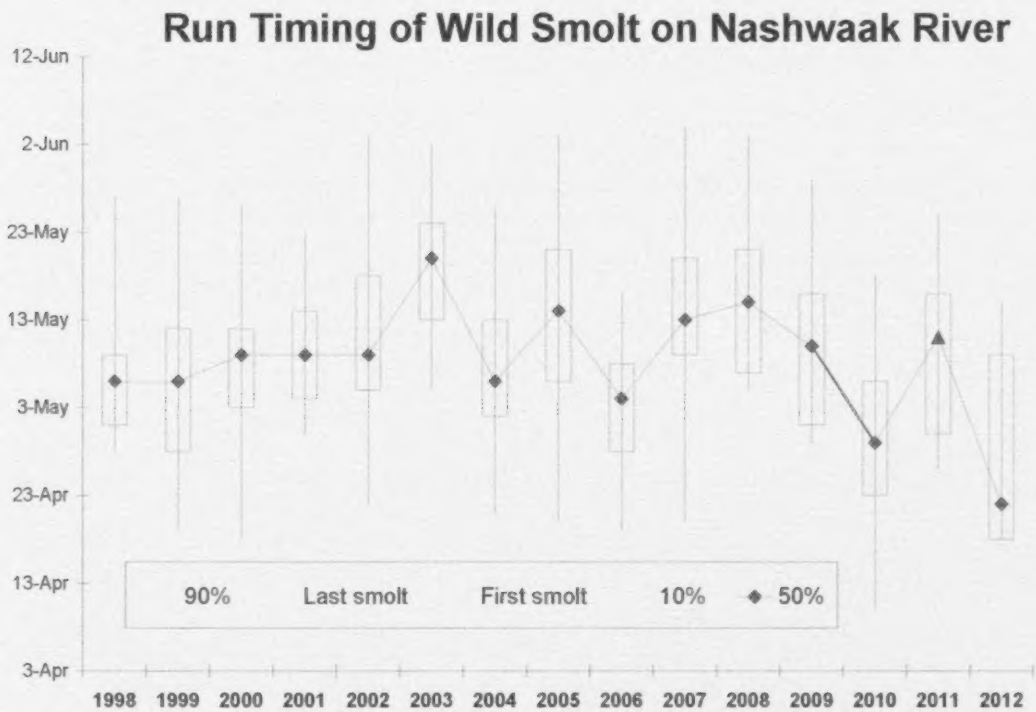


Figure 20: Distribution of smolt RST captures on the Nashwaak River by date and year; showing the first and last smolts captured, as well as the 10%, 50% and 90% cumulative proportion of catch from 1998 to 2012.

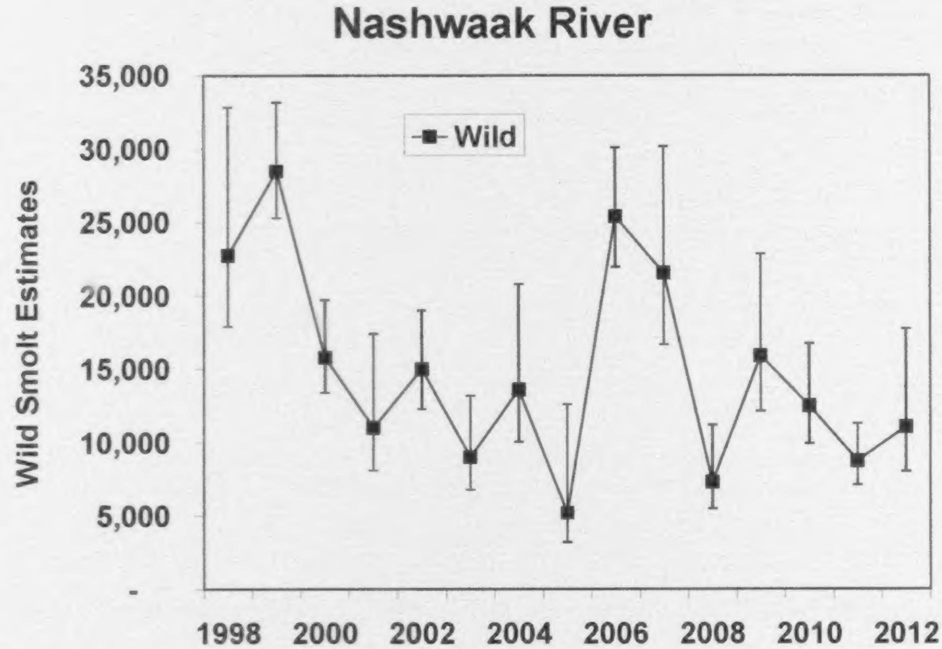


Figure 21: Estimated numbers of wild smolts (and 2.5 and 97.5 percentiles) emigrating from the Nashwaak River, 1998-2012.

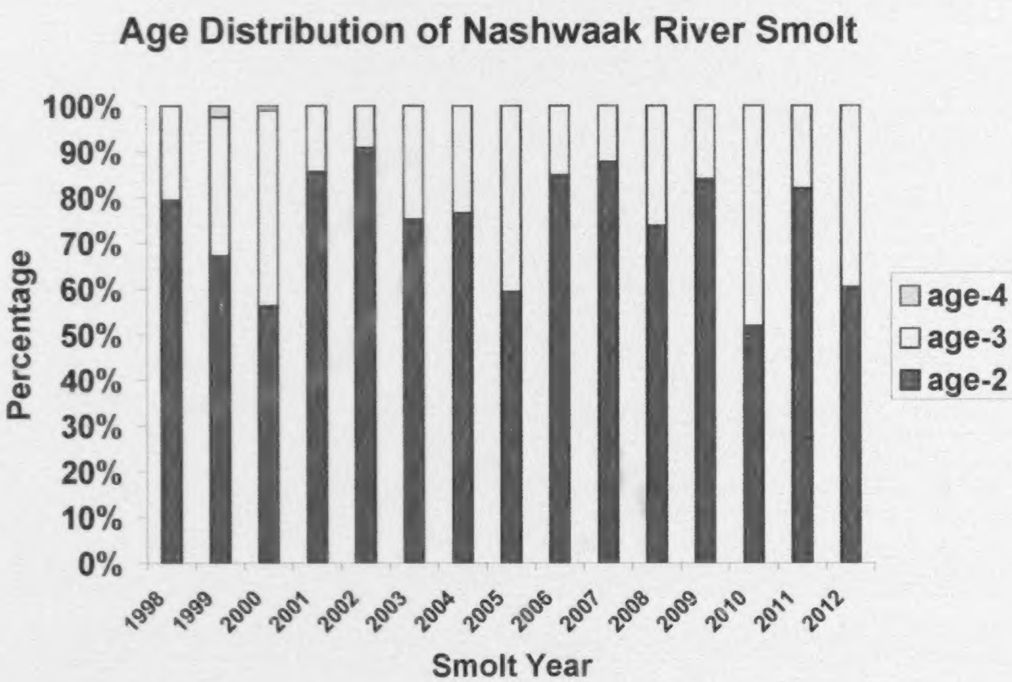


Figure 22: Percentages of age-2, age-3 and age-4 wild smolts emigrating from the Nashwaak River, 1998-2012.

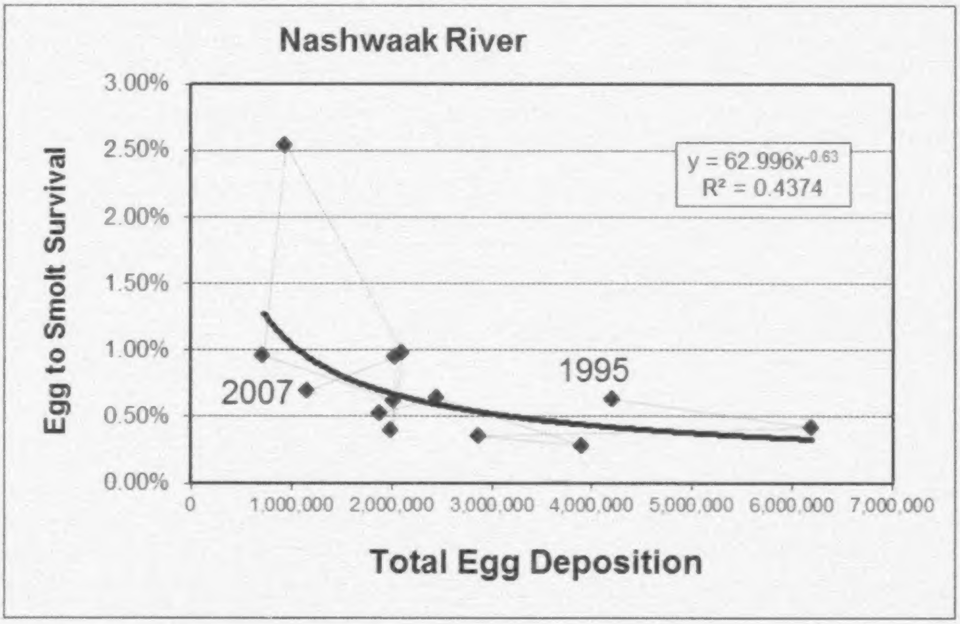


Figure 23a: Egg-to-smolt survival on the Nashwaak River, 1995 – 2007.

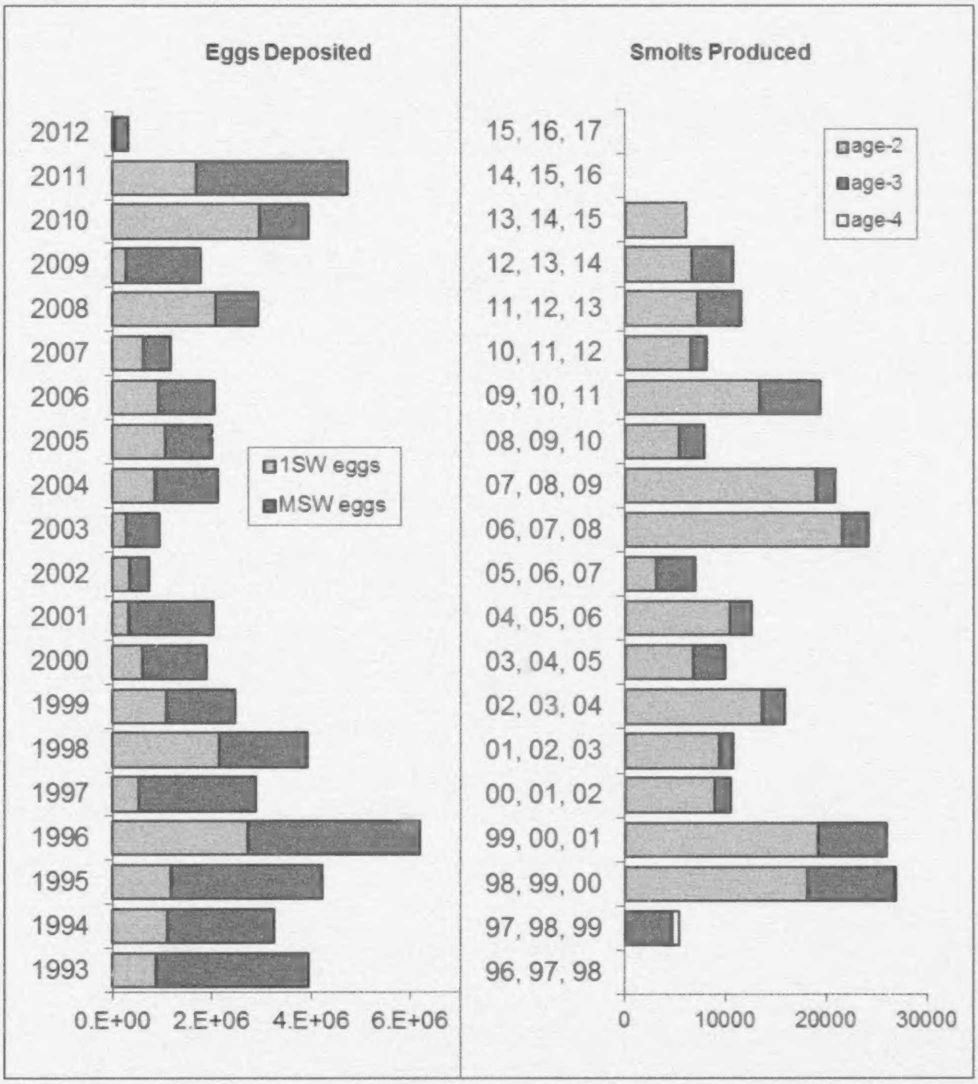


Figure 23b: Egg deposition estimates for 1SW and MSW spawners on the Nashwaak River from 1993 to 2012 (left panel) and corresponding smolt outputs (1998-2012) by age (right panel). Note: Incomplete smolt cohort (age-2 smolts from 1994 spawners; age-3 and age-4 smolts from 2009 spawners.

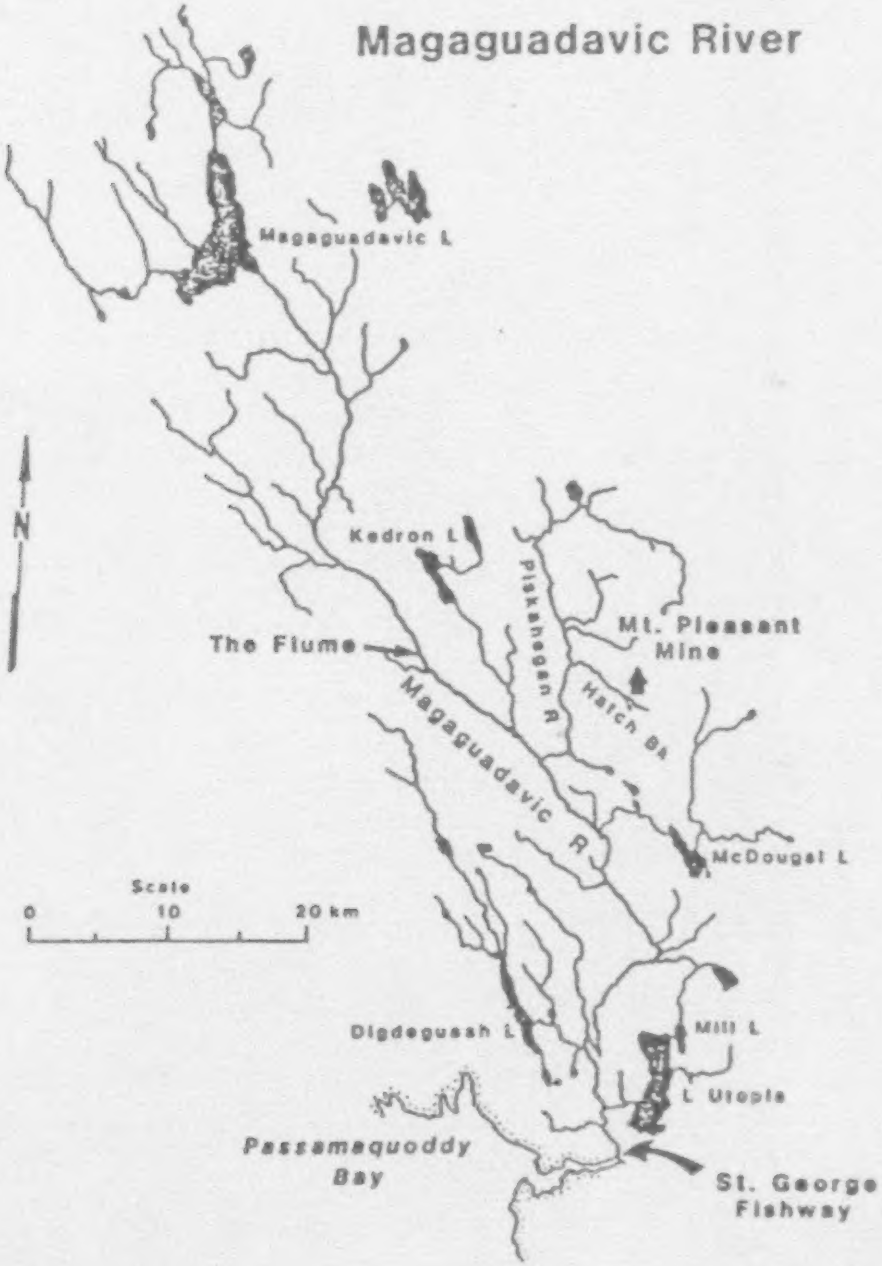


Figure 24: Map of the Magaguadavic Watershed.

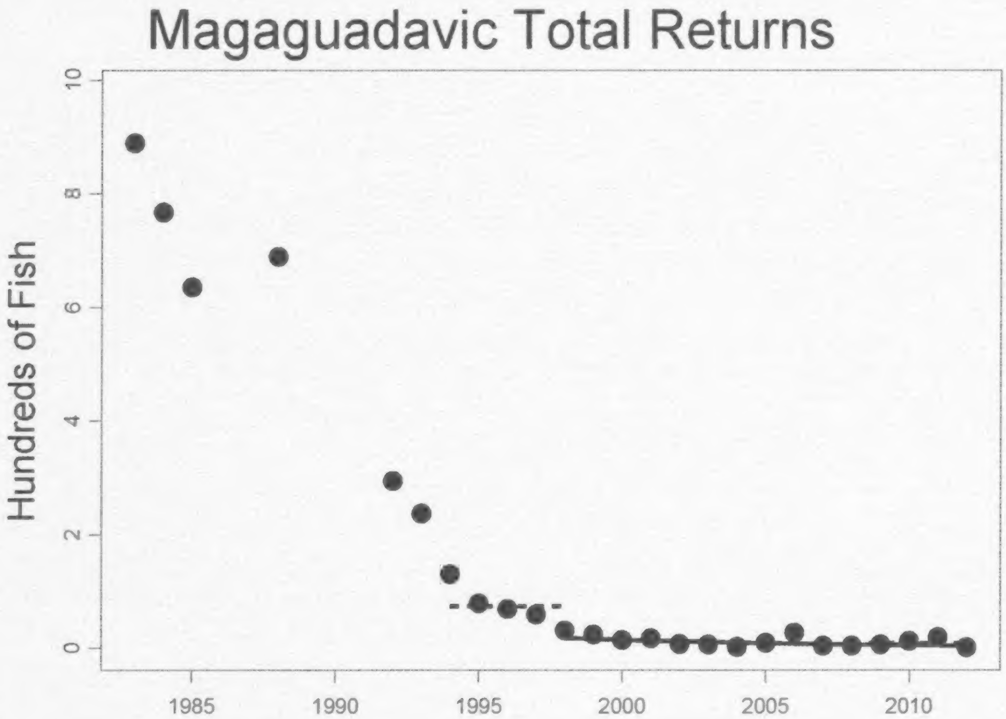


Figure 25: Trends in abundance of Atlantic Salmon returns in the Magaguadavic River. The solid line is the predicted abundance from a log-linear model fit by least squares over the last 15-year time period. The dashed lines show the 5-year mean abundance for two time periods ending in 1998 and 2012. The points are the observed data. Model coefficients are provided in Table 8.

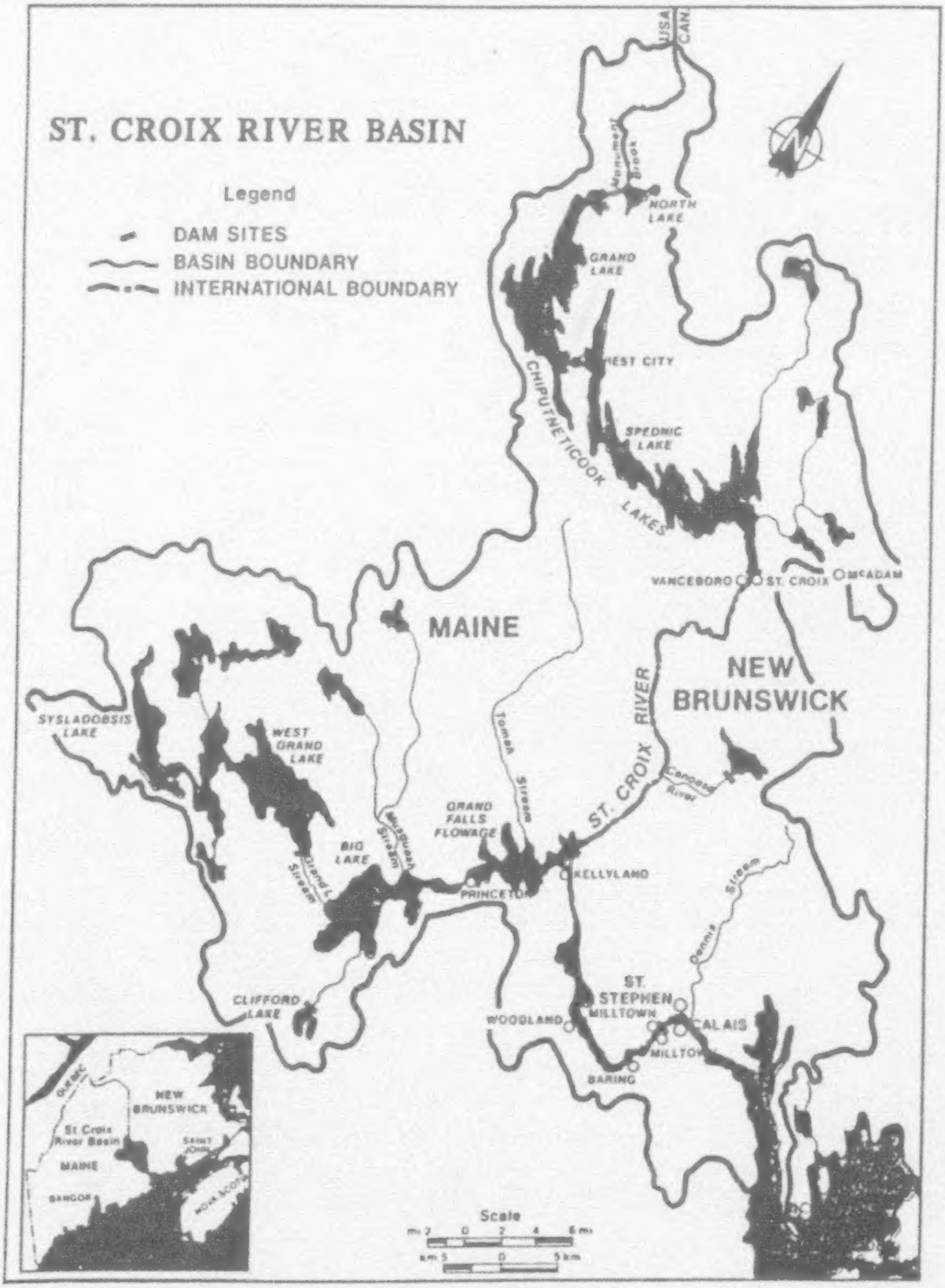


Figure 26: Map of the St. Croix Watershed.

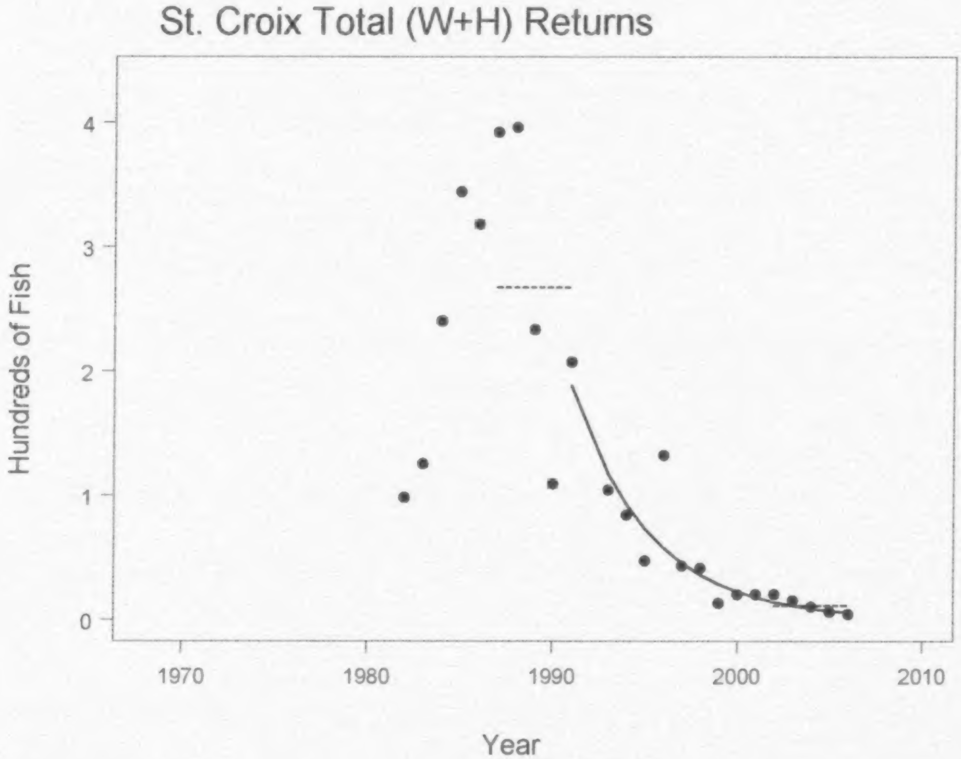


Figure 27: Trends in abundance of adult Atlantic Salmon in the St. Croix River from Jones et al. (2010). The solid line is the predicted abundance from a log-linear model fit by least squares for the last 15 years assessed (1992-2006). The dashed lines show the 5-year mean abundance for two time periods ending in 1991 and 2008. The points are the observed data.

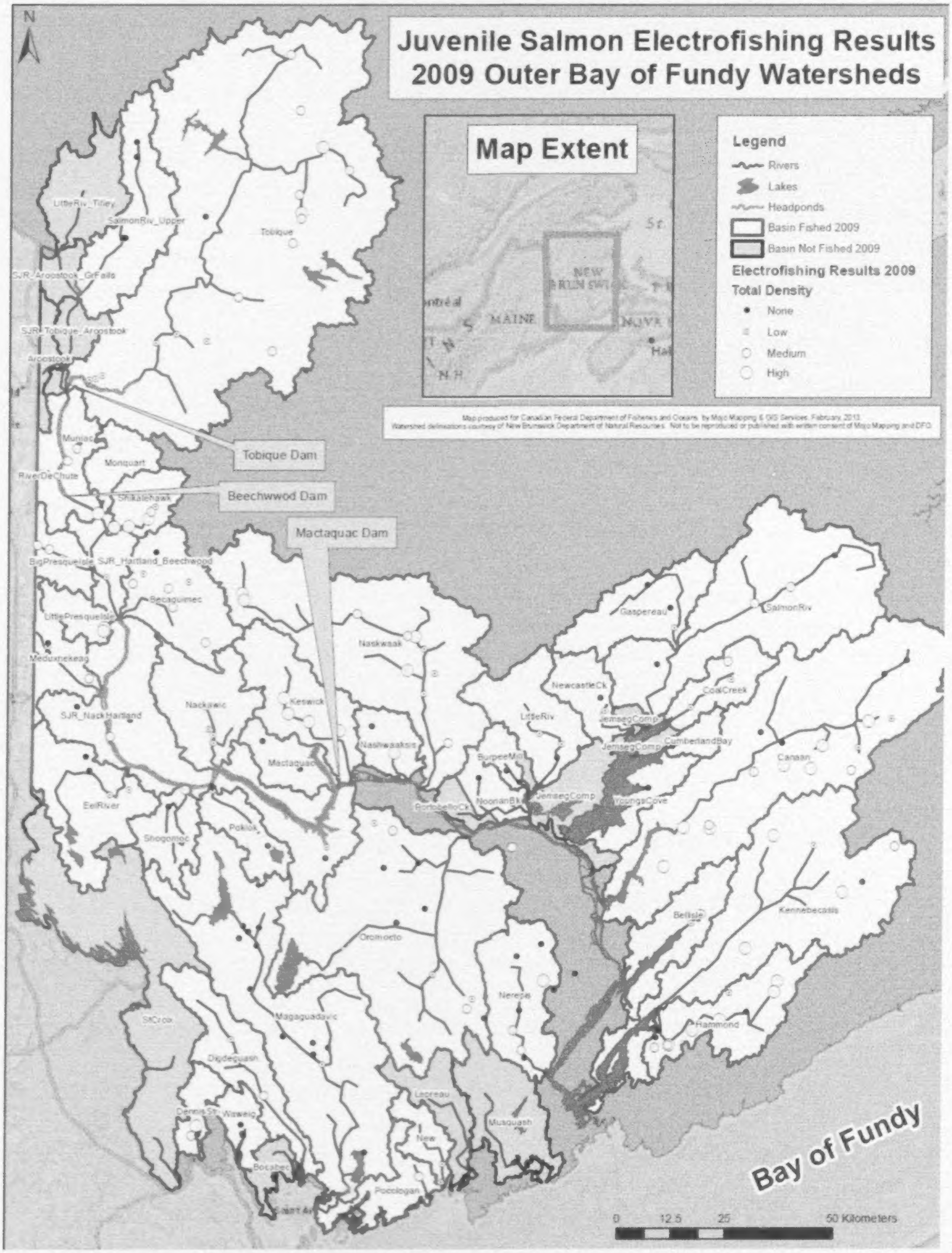


Figure 28: Densities (fish per 100 m^2) of wild juvenile salmon as determined from electrofishing surveys conducted within rivers located within DU 16 (OBoF population) in 2009.

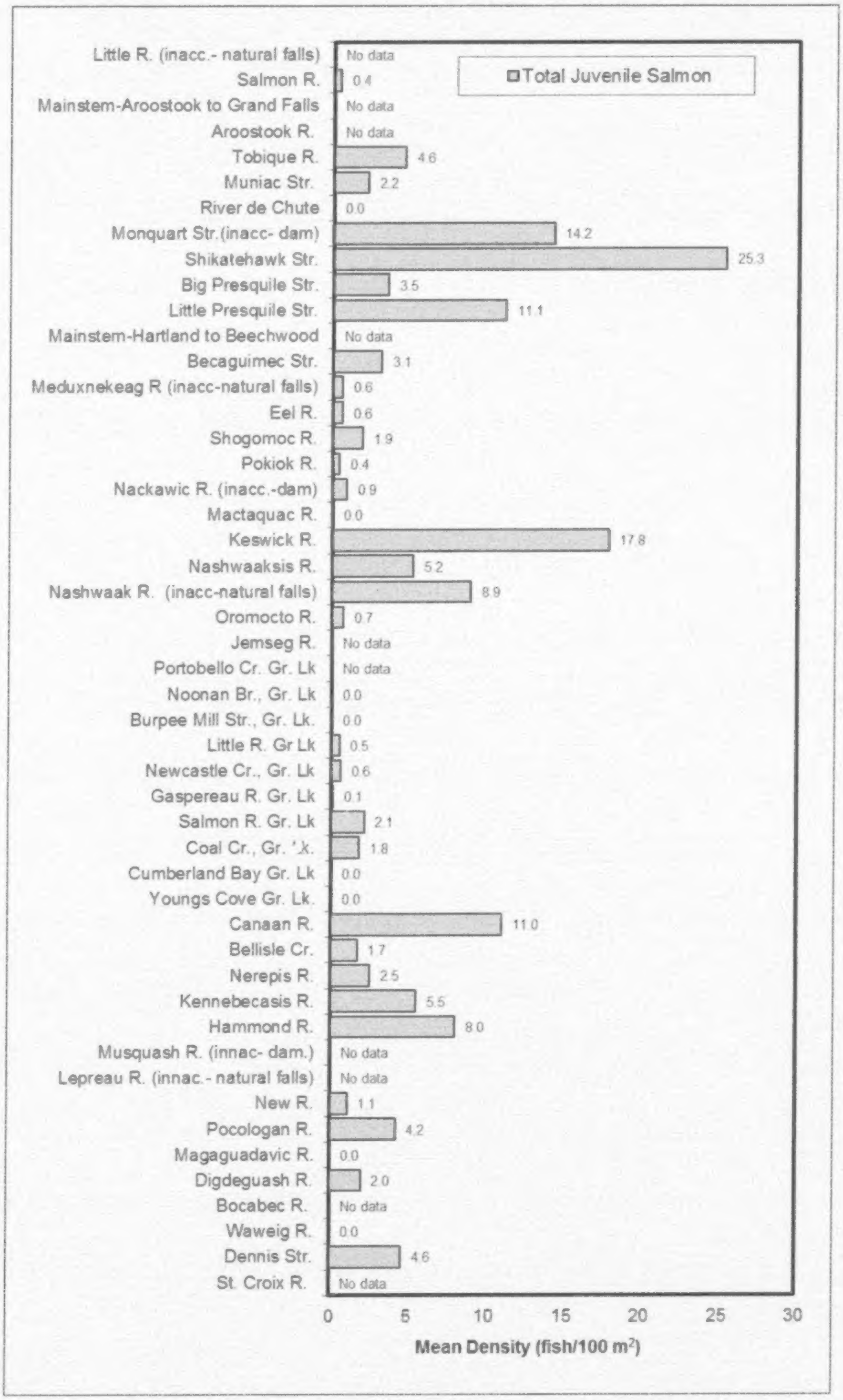


Figure 29: Mean density of juvenile salmon (age classes combined) for populations within DU 16. Results are for 2009 only and not all rivers were surveyed (latter identified by' No data').

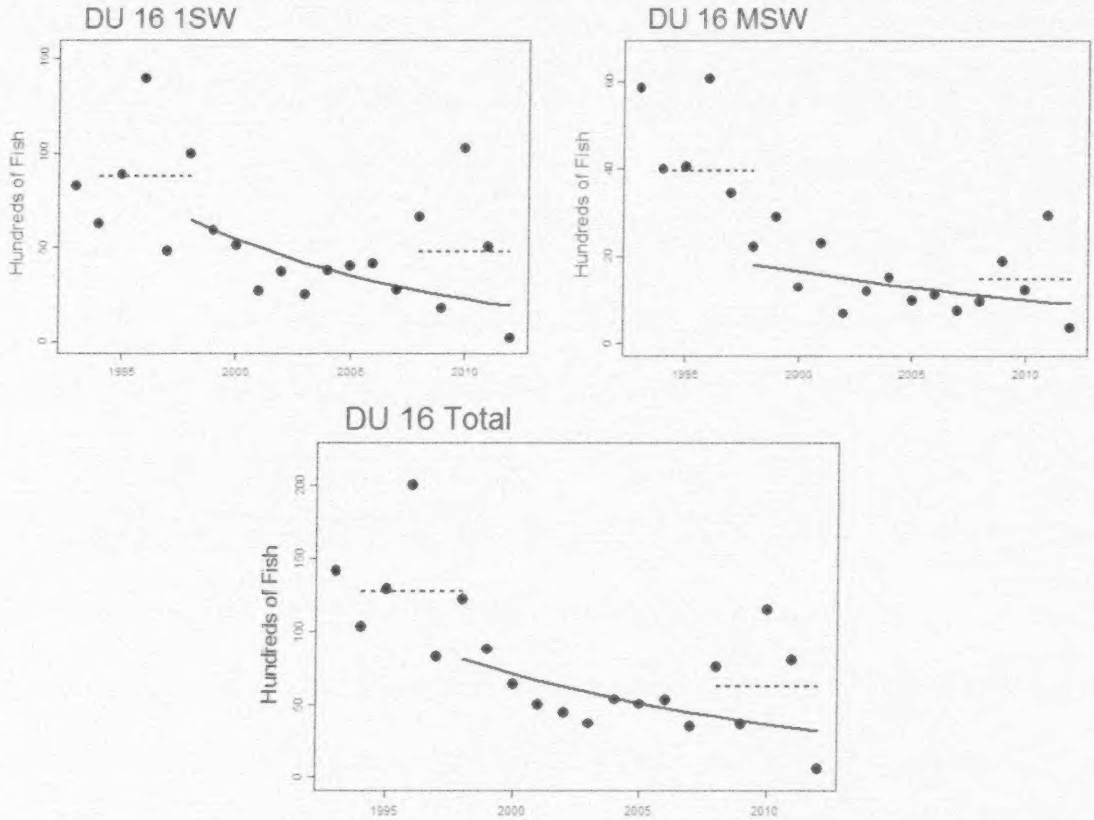


Figure 30: Trends in abundance of Atlantic Salmon returns in DU 16. The solid line is the predicted abundance from a log-linear model fit by least squares for the last 15 years. The dashed lines show the 5-year mean abundance for two time periods ending in 1998 and 2012. The points are the observed data. Model coefficients are provided in Table 8.

APPENDICES

APPENDIX 1

Terms of Reference

Recovery Potential Assessment for Atlantic Salmon (Outer Bay of Fundy Designatable Unit)

Context

When the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designates aquatic species as threatened or endangered, Fisheries and Oceans Canada (DFO), as the responsible jurisdiction under the *Species at Risk Act* (SARA), is required to undertake a number of actions. Many of these actions require scientific information on the current status of the species, population or designable unit (DU), threats to its survival and recovery, and the feasibility of its recovery. Formulation of this scientific advice has typically been developed through a Recovery Potential Assessment (RPA) that is conducted shortly after the COSEWIC assessment. This timing allows for the consideration of peer-reviewed scientific analyses into SARA processes including recovery planning.

The Outer Bay of Fundy DU of Atlantic Salmon was evaluated as Endangered by COSEWIC in November 2010. The rationale for designation is as follows: "This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers tributary to the New Brunswick side of the Bay of Fundy, from the U.S. border to the Saint John River. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 57% and 82%, respectively, for a net decline of all mature individuals of about 64%; moreover, these declines represent continuations of greater declines extending far into the past. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Current threats include poor marine survival related to substantial but incompletely understood changes in marine ecosystems, and negative effects of interbreeding or ecological interactions with escaped domestic salmon from fish farms. The rivers used by this population are close to the largest concentration of salmon farms in Atlantic Canada." There has been no previous RPA for this DU.

In support of listing recommendations for this DU by the Minister, DFO Science has been asked to undertake an RPA, based on the National Frameworks (DFO 2007a and b). The advice in the RPA may be used to inform both scientific and socio-economic elements of the listing decision, as well as development of a recovery strategy and action plan, and to support decision-making with regards to the issuance of permits, agreements and related conditions, as per section 73, 74, 75, 77 and 78 of SARA. The advice generated via this process will also update and/or consolidate any existing advice regarding this DU.

Objectives

- To assess the recovery potential of the Outer Bay of Fundy DU of Atlantic Salmon.

Assess current/recent species/ status

1. Evaluate present status for abundance and range and number of populations.
2. Evaluate recent species trajectory for abundance (i.e., numbers and biomass focusing on mature individuals) and range and number of populations.

3. Estimate, to the extent that information allows, the current or recent life-history parameters (total mortality, natural mortality, fecundity, maturity, recruitment, etc.) or reasonable surrogates; and associated uncertainties for all parameters.
4. Estimate expected population and distribution targets for recovery, according to DFO guidelines (DFO 2005, and 2011).
5. Project expected population trajectories over three generations (or other biologically reasonable time), and trajectories over time to the recovery target (if possible to achieve), given current parameters for population dynamics and associated uncertainties using DFO guidelines on long-term projections (Shelton et al. 2007).
6. Evaluate residence requirements for the species, if any.

Assess the Habitat Use

7. Provide functional descriptions (as defined in DFO 2007b) of the required properties of the aquatic habitat for successful completion of all life-history stages.
8. Provide information on the spatial extent of the areas that are likely to have these habitat properties.
9. Identify the activities most likely to threaten the habitat properties that give the sites their value, and provide information on the extent and consequences of these activities.
10. Quantify how the biological function(s) that specific habitat feature(s) provide to the species varies with the state or amount of the habitat, including carrying capacity limits, if any.
11. Quantify the presence and extent of spatial configuration constraints, if any, such as connectivity, barriers to access, etc.
12. Provide advice on how much habitat of various qualities / properties exists at present.
13. Provide advice on the degree to which supply of suitable habitat meets the demands of the species both at present, and when the species reaches biologically based recovery targets for abundance and range and number of populations.
14. Provide advice on feasibility of restoring habitat to higher values, if supply may not meet demand by the time recovery targets would be reached, in the context of all available options for achieving recovery targets for population size and range.
15. Provide advice on risks associated with habitat "allocation" decisions, if any options would be available at the time when specific areas are designated as critical habitat.
16. Provide advice on the extent to which various threats can alter the quality and/or quantity of habitat that is available.

Scope for Management to Facilitate Recovery

17. Assess the probability that the recovery targets can be achieved under current rates of parameters for population dynamics, and how that probability would vary with different mortality (especially lower) and productivity (especially higher) parameters.
18. Quantify to the extent possible the magnitude of each major potential source of mortality identified in the pre-COSEWIC assessment, the COSEWIC Status Report, information from DFO sectors, and other sources.
19. Quantify to the extent possible the likelihood that the current quantity and quality of habitat is sufficient to allow population increase, and would be sufficient to support a population that has reached its recovery targets.

20. Assess to the extent possible the magnitude by which current threats to habitats have reduced habitat quantity and quality.

Scenarios for Mitigation and Alternative to Activities

21. Using input from all DFO sectors and other sources as appropriate, develop an inventory of all feasible measures to minimize/mitigate the impacts of activities that are threats to the species and its habitat (steps 18 and 20).
22. Using input from all DFO sectors and other sources as appropriate, develop an inventory of all reasonable alternatives to the activities that are threats to the species and its habitat (steps 18 and 20).
23. Using input from all DFO sectors and other sources as appropriate, develop an inventory of activities that could increase the productivity or survivorship parameters (steps 3 and 17).
24. Estimate, to the extent possible, the reduction in mortality rate expected by each of the mitigation measures in step 21 or alternatives in step 22 and the increase in productivity or survivorship associated with each measure in step 23.
25. Project expected population trajectory (and uncertainties) over three generations (or other biologically reasonable time), and to the time of reaching recovery targets when recovery is feasible; given mortality rates and productivities associated with specific scenarios identified for exploration (as above). Include scenarios which provide as high a probability of survivorship and recovery as possible for biologically realistic parameter values.
26. Recommend parameter values for population productivity and starting mortality rates, and where necessary, specialized features of population models that would be required to allow exploration of additional scenarios as part of the assessment of economic, social, and cultural impacts of listing the species.

Allowable Harm Assessment

27. Evaluate maximum human-induced mortality which the species can sustain and not jeopardize survival or recovery of the species.

References Cited

COSEWIC. 2010. COSEWIC assessment and status report on the Atlantic Salmon *Salmo salar* (Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspé-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xlvii + 136 p.

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Appendix 2. Numbers of juvenile hatchery salmon and wild captive-reared adults distributed to sites up river of Mactaquac Dam (excluding distributions to the Aroostook River), 1976-2012. Fry are between zero and 14 weeks old, 0+ parr are at least 14 weeks old but less than one year old, and 1+ parr are at least one year old but less than two years old. Period (.) equals no data.

	0+ Fry		0+ Parr		1+ Parr			1 yr smolt			2 yr smolt			Captive Reared Adults			
Year	No Mark	Ad Clip	No Mark	Ad Clip	No Mark	Ad Clip	Tagged	No Mark	Ad Clip	Tagged	No Mark	Ad Clip	Tagged	1 yr	2 yr	3 yr	Repeats
1976	.	.	.	.	.	52,662	5,000	.	.	.	.	.	.	.	.	.	.
1977	.	.	6,042	44,021	.	.	.	.	.	.	.	.	.	.	.	.	.
1978	.	.	9,163	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1979	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1980	.	.	.	.	.	.	.	.	.	.	.	.	5,995	.	.	.	.
1981	.	.	.	.	.	.	.	.	.	.	.	.	5,998	.	.	.	.
1982	.	.	75,210	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1983	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1984	.	.	123,757	8,517	.	.	.	.	.	.	.	.	.	.	.	.	.
1985	.	.	164,947	110,569	24,544	.	.	.	.	.	.	.	.	.	.	.	.
1986	17,300	.	126,692	91,808	.	.	.	.	.	.	.	.	.	.	.	.	.
1987	266,257	.	101,052	50,283	.	.	.	.	.	.	.	.	.	.	.	.	.
1988	79,948	.	107,478	60,472	.	.	.	.	.	.	.	.	.	.	.	.	.
1989	150,384	.	151,562	.	.	.	.	4,680	30,011	.	20,000	.	.	.	.	.	.
1990	164,005	.	232,291	.	.	.	.	2,877	24,026	.	.	17,140	.	.	.	.	.
1991	227,535	.	499,130	.	.	.	.	.	30,181	.	.	19,646	.	.	.	.	.
1992	600,408	.	514,662	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1993	672,797	.	272,824	99,939	.	.	.	819	.	.	.	.	.	.	.	.	.
1994	983,549	30,000	285,988	253,730	.	.	.	.	.	.	.	.	.	.	.	.	.
1995	642,830	.	193,208	226,391	.	.	.	.	.	.	.	.	.	.	.	.	.
1996	940,962	.	511,771	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1997	504,488	.	391,860	20,991	.	.	.	.	.	.	.	.	.	.	.	.	.
1998	213,973	.	.	282,491	.	.	.	.	.	.	.	.	.	.	.	.	.
1999	172,220	.	.	356,635	.	.	.	.	.	.	.	.	.	.	.	.	.
2000	609,802	.	.	371,751	.	.	.	.	1,996	.	.	.	.	.	.	.	.
2001	8,330	.	.	344,618	.	.	.	.	.	.	.	.	.	.	.	.	.
2002	500	.	.	342,176	.	.	.	.	.	2,357	.	.	.	.	.	.	.
2003	2,723	.	.	261,852	.	.	.	.	.	1,483	.	.	.	387	.	.	.
2004	87,936	.	122,196	129,147	.	.	.	.	.	.	.	.	.	240	847	.	.
2005	.	.	2,500	206,533	.	.	.	1,400	.	.	.	.	.	202	847	128	39
2006	1,294	.	.	310,947	.	.	.	.	.	1,986	.	.	.	224	803	143	119
2007	.	.	.	157,142	.	.	.	.	.	1,999	.	.	.	268	413	114	195
2008	.	.	59,185	121,299	.	.	.	.	.	1,968	.	.	.	69	617	141	88
2009	12,061	.	2,500	178,096	.	.	.	.	.	1,988	.	.	.	156	458	322	412
2010	.	.	2,500	188,895	.	4,253	1,004	.	.	1,818	.	.	.	381	404	79	170
2011	.	.	183,041	.	.	.	2879	996	.	.	.	.	.	331	398	135	232
2012	3487	.	158,220	.	78	.	.	2,000	.	.	.	.	.	0	1056	232	162
Total	**6,362,789**	**30,000**	**4,297,779**	**4,218,303**	**24,622**	**56,915**	**8,883**	**12,772**	**86,214**	**13,599**	**20,000**	**36,786**	**11,993**	**2,258**	**5,843**	**1,294**	**1,417**

Appendix 3. Numbers of juvenile hatchery salmon and wild captive-reared adults distributed to sites on the Tobique River, 1976-2012. Fry are between zero and 14 weeks old, 0+ parr are at least 14 weeks old but less than one year old and 1+ parr are at least one year old but less than two years old. Period (.) equals no data.

	0+ Fry		0+ Parr		1+ Parr			1 yr smolt			2 yr smolt			Captive Reared Adults			
Year	No Mark	Ad Clip	No Mark	Ad Clip	No Mark	Ad Clip	Tagged	No Mark	Ad Clip	Tagged	No Mark	Ad Clip	Tagged	1 yr	2 yr	3 yr	Repeats
1976	.	.	.	.	.	.	5,000	.	.	.	.	.	.	.	.	.	.
1977	.	.	6,042	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1978	.	.	9,163	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1979	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1980	.	.	.	.	.	.	.	.	.	.	.	.	5,995	.	.	.	.
1981	.	.	.	.	.	.	.	.	.	.	.	.	5,998	.	.	.	.
1982	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1983	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1984	.	.	.	8,517	.	.	.	.	.	.	.	.	.	.	.	.	.
1985	.	.	43,211	38,687	.	.	.	.	.	.	.	.	.	.	.	.	.
1986	17,300	.	46,563	53,782	.	.	.	.	.	.	.	.	.	.	.	.	.
1987	52,882	.	33,505	21,950	.	.	.	.	.	.	.	.	.	.	.	.	.
1988	.	.	28,723	40,038	.	.	.	.	.	.	.	.	.	.	.	.	.
1989	80,012	.	83,846	.	.	.	.	2,255	9,995	.	.	.	.	.	.	.	.
1990	68,707	.	83,075	.	.	.	.	534	9,944	.	.	.	.	.	.	.	.
1991	.	.	194,173	.	.	.	.	.	4,995	.	.	4,953	.	.	.	.	.
1992	119,987	.	257,732	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1993	203,950	.	98,738	99,939	.	.	.	819	.	.	.	.	.	.	.	.	.
1994	317,996	30,000	46,376	253,730	.	.	.	.	.	.	.	.	.	.	.	.	.
1995	337,080	.	101,900	207,683	.	.	.	.	.	.	.	.	.	.	.	.	.
1996	651,045	.	333,320	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1997	302,000	.	256,578	20,991	.	.	.	.	.	.	.	.	.	.	.	.	.
1998	83,995	.	.	193,756	.	.	.	.	.	.	.	.	.	.	.	.	.
1999	101,204	.	.	209,358	.	.	.	.	.	.	.	.	.	.	.	.	.
2000	360,390	.	.	254,473	.	.	.	.	1,996	.	.	.	.	.	.	.	.
2001	.	.	.	221,014	.	.	.	.	.	.	.	.	.	.	.	.	.
2002	500	.	.	184,349	.	.	.	.	.	2,357	.	.	.	.	.	.	.
2003	2,723	.	.	181,630	.	.	.	.	.	1,483	.	.	.	339	.	.	.
2004	.	.	78,052	129,147	.	.	.	.	.	.	.	.	.	213	797	.	.
2005	.	.	2,500	179,713	.	.	.	1,400	.	.	.	.	.	202	577	128	39
2006	.	.	.	310,947	.	.	.	.	.	1,986	.	.	.	224	720	115	119
2007	.	.	.	157,142	.	.	.	.	.	1,999	.	.	.	230	380	114	195
2008	.	.	59,185	121,299	.	.	.	.	.	1,968	.	.	.	69	358	94	88
2009	.	.	2,500	178,096	.	.	.	.	.	1,988	.	.	.	156	458	322	412
2010	.	.	2,500	188,895	.	4,253	1,004	.	.	1,818	.	.	.	381	404	79	170
2011	.	.	183,041	.	.	.	.	996	.	.	.	.	.	302	362	96	232
2012	.	.	150,166	.	.	.	.	2,000	.	.	.	.	.	0	928	214	0
Total	2,699,771	30,000	2,100,889	3,255,136	0	4,253	6,004	8,004	26,930	13,599	0	4,953	11,993	2,116	4,984	1,162	1,255

Appendix 4. Adjusted counts by age of wild and hatchery 1SW and MSW salmon to Mactaquac Dam, 1995-2012.

Category Origin	Smolt Sea Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1SW Salmon																			
Wild	2.1	957	601	150	147	150	823	485	368	270	404	549	553	396	554	279	1,384	358	36
	3.1	1,154	585	146	185	290	459	191	258	103	415	285	232	91	232	143	307	209	12
	4.1	43	28	32	7	27	48	3	2	4	36	20	4	0	2	11	0	9	0
Wild Total		**2,154**	**1,214**	**328**	**338**	**467**	**1,330**	**679**	**628**	**377**	**855**	**854**	**789**	**487**	**788**	**433**	**1,691**	**576**	**48**
Hatchery	1.1	1,509	2,649	1,543	2,112	1,672	1,403	839	1,358	815	499	197	426	273	686	97	444	51	4
	2.1	834	1,354	521	968	480	207	129	263	83	98	79	65	116	213	55	187	216	16
	3.1	483	867	627	1,459	569	66	35	86	13	19	14	40	15	96	19	48	158	7
	4.1	2	69	88	56	36	32	1	0	1	1	3	0	3	0	3	0	8	6
Hatchery Total		**2,828**	**4,939**	**2,778**	**4,595**	**2,757**	**1,708**	**1,004**	**1,707**	**912**	**617**	**293**	**531**	**407**	**995**	**174**	**679**	**433**	**33**
1SW Salmon	**Total**	**4,982**	**6,153**	**3,106**	**4,933**	**3,224**	**3,038**	**1,683**	**2,335**	**1,289**	**1,472**	**1,147**	**1,320**	**894**	**1,783**	**607**	**2,370**	**1,009**	**81**
MSW Salmon																			
Wild	2.2	976	1,128	428	64	359	137	507	124	160	348	149	249	148	113	280	223	251	54
	3.2	523	925	473	145	412	58	91	29	55	38	87	25	52	21	40	39	36	4
	4.2	35	13	26	1	16	2	1	0	0		0	0	0	0	0	0	0	0
Previous Spawners and 3SW		59	114	68	101	28	73	29	41	19	4	12	2	0	5	9	6	0	11
Wild Total		**1,593**	**2,181**	**995**	**312**	**816**	**270**	**628**	**194**	**234**	**390**	**248**	**276**	**200**	**139**	**329**	**268**	**287**	**69**
Hatchery	1.2	398	567	412	229	554	173	462	142	443	265	78	44	89	71	139	76	34	22
	2.2	95	221	143	120	209	57	49	22	38	32	13	14	33	61	57	37	292	32
	3.2	47	137	158	177	158	19	9	2	10	5	1	2	6	3	9	9	48	5
	4.2	2	10	4	13	3	1	0	0	0	0	0	0	0	0	0	0	0	0
Previous Spawners and 3SW		30	13	26	92	19	10	28	7	7	2	2	2	0	0	10	5	0	0
Hatchery Total		**572**	**947**	**744**	**631**	**943**	**260**	**548**	**173**	**498**	**304**	**94**	**62**	**128**	**135**	**215**	**127**	**374**	**59**
MSW Salmon Total		**2,165**	**3,128**	**1,739**	**943**	**1,759**	**530**	**1,176**	**367**	**732**	**694**	**342**	**338**	**328**	**274**	**544**	**395**	**661**	**128**
TOTALS		**7,147**	**9,281**	**4,845**	**5,876**	**4,983**	**3,568**	**2,859**	**2,702**	**2,021**	**2,166**	**1,489**	**1,658**	**1,222**	**2,057**	**1,151**	**2,765**	**1,670**	**209**
Total Mean Age- Wild only		**3.90**	**4.16**	**4.32**	**4.32**	**4.24**	**3.64**	**3.75**	**3.70**	**3.73**	**3.75**	**3.63**	**3.52**	**3.51**	**3.44**	**3.73**	**3.32**	**3.64**	**3.97**
Prop of MSW that are 2SW		**0.96**	**0.96**	**0.95**	**0.79**	**0.97**	**0.84**	**0.95**	**0.87**	**0.96**	**0.99**	**0.96**	**0.99**	**1.00**	**0.98**	**0.97**	**0.97**	**1.00**	**0.91**

Appendix 5. Numbers of juvenile hatchery salmon distributed to sites within the Nashwaak River, 1976-2008. Fry are between zero and 14 weeks old, 0+ parr are at least 14 weeks old but less than one year old and 1+ parr are at least one year old but less than two years old. Period (.) equals no data.

	0+ Fry		0+ Parr		1+ Parr		1+ Smolt			2+ Smolt		
Year	No Mark	Ad Clip	No Mark	Ad clip	No Mark	Ad Clip	No Mark	Ad clip	Tagged	No Mark	Ad Clip	Tagged
1976	203,265	.	18,964	.	11,117	1,210	.	.	.	.	.	.
1977	137,187	650	22,044	.	7,200	3,196	.	.	.	.	.	.
1978	.	.	106,375	.	1,320	.	.	.	.	.	.	.
1979	.	.	85,113	.	22,476	.	.	.	.	.	.	.
1980	134,884	.	.	.	18,240	.	.	.	.	.	.	.
1981	.	.	.	.	25,254	32,880	.	.	.	20,336	.	.
1982	.	.	57,750	.	.	.	.	.	.	5,183	12,776	.
1983	.	.	.	.	.	.	.	.	.	.	8,053	7,998
1984	.	.	47,129	.	.	.	.	.	.	.	12,158	8,005
1985	11,000	.	13,043	.	46,643	12,344	.	.	7,966	.	.	.
1986	.	.	23,071	.	.	.	18,734	.	.	.	.	.
1987	71,614	.	17,931	.	.	.	13,205	.	6,500	.	.	.
1988	121,711	.	17,114	.	.	.	16,788	.	4,001	.	.	.
1989	13,703	.	50,508	.	.	.	11,914	.	.	.	.	.
1990	47,172	.	25,568	.	.	.	15,248	.	3,999	.	.	.
1991	16,397	.	18,102	.	.	.	15,903	.	4,000	.	.	.
1992	26,302	.	26,553	.	.	.	9,658	.	3,995	.	.	.
1993	17,310	.	22,500	.	.	.	9,270	.	3,881	.	.	.
1994	51,320	.	16,817	.	.	.	11,059	.	4,000	.	.	.
1995	32,450	.	16,802	.	.	.	6,633	.	6,648	.	.	.
1996	.	.	.	.	.	.	[a]9,027	.	3,004	.	.	.
1997	.	.	.	.	.	.	.	.	.	.	.	.
1998	.	.	.	.	.	.	.	.	.	.	.	.
1999	2,500	.	.	6,000	.	.	.	.	.	.	.	.
2000	8,424	.	.	6,000	.	.	.	.	.	.	.	.
2001	7,009	.	.	11,713	.	.	.	.	.	.	.	.
2002	.	.	.	3,837	.	.	.	.	2,148	.	.	.
2003	2,693	.	7,000	21,491	.	.	.	4,918	1,780	.	.	.
2004	.	.	.	.	.	.	.	.	.	.	.	.
2005	2,439	.	.	10,000	.	.	.	.	.	.	.	.
2006	6,000	.	.	33,689	.	.	.	.	.	.	.	.
2007	41,643	.	.	21,998	.	.	.	.	.	.	.	.
2008	11,000	.	.	16,000	.	.	.	.	.	.	.	.
2009	35,703	.	.	.	.	.	.	.	.	.	.	.
2010	.	.	33,045	7,103	.	.	.	.	.	.	.	.
2011	.	.	.	.	.	.	.	.	.	.	.	.
2012	.	.	.	.	.	.	.	.	.	.	.	.
Total	**1,001,726**	**650**	**625,429**	**137,831**	**132,250**	**49,630**	**137,439**	**4,918**	**51,922**	**25,519**	**32,987**	**16,003**

Key:
[a] - 3,014 one year old smolt were released from the Mactaquac Migration Channel.

Appendix 6. Numbers of juvenile hatchery salmon and wild captive-reared adults distributed to sites within the Magaguadavic River, 1976-2012. Fry are between zero and 14 weeks old, 0+ parr are at least 14 weeks old but less than one year old and 1+ parr are at least one year old but less than two years old. Period (.) equals no data.

Year	0+ Fry		0+ Parr		1+ Parr		1+ Smolt			2+ Smolt			Captive Reared Adults			
	No Mark	Ad Clip	No Mark	Ad clip	No Mark	Ad Clip	No Mark	Ad clip	Tagged	No Mark	Ad Clip	Tagged	1 yr	2 yr	3 yr	Kelts
1976-86	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1987	.	.	14,644	.	.	.	.	.	.	.	.	.	.	.	.	.
1988	.	.	.	.	.	.	2,034	.	.	.	.	.	.	.	.	.
1989	.	.	.	.	.	.	.	.	.	5,771	5,000	.	.	.	.	.
1990	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1991	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1992	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1993	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1994	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1995	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1996	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1997	.	.	.	2,767	.	.	.	.	.	.	.	.	.	.	.	.
1998	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1999	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2002	29,033	.	.	.	.	.	.	.	.	.	.	.	.	99	.	.
2003	20,556	.	5,000	7,336	.	.	.	.	.	.	.	.	.	.	.	.
2004	24,873	.	.	8,434	.	.	.	1,828	.	.	.	.	.	.	.	.
2005	6,656	.	.	2,007	.	.	.	896	.	.	.	.	.	.	.	.
2006	.	.	.	.	.	.	.	924	.	.	.	.	.	.	.	.
2007	88,099	.	.	9,899	.	.	.	.	.	.	706	.	.	.	.	49
2008	75,000	.	.	6,700	.	.	.	.	1,593	.	.	.	.	.	.	17
2009	238,071	.	.	.	.	.	.	.	812	.	.	.	.	.	.	30
2010	.	.	.	.	.	.	.	.	1,989	.	.	.	.	.	.	.
2011	139,150	.	.	.	.	.	588	.	.	.	.	.	.	.	36	.
2012	140,000	.	.	9,778	.	.	.	.	.	.	.	.	.	.	.	263
Total	**761,438**	**-**	**19,644**	**46,921**	**-**	**-**	**2,622**	**3,648**	**4,394**	**5,771**	**5,706**	**-**	**-**	**99**	**36**	**359**

Appendix 7. Numbers of juvenile hatchery salmon and wild captive-reared adults distributed to sites within the St. Croix River, 1976 – 2012. Fry are between zero and 14 weeks old, 0+ parr are at least 14 weeks old but less than one year old and 1+ parr are at least one year old but less than two years old. Period (.) equals no data.

		0+ Fry		0+ Parr		1+ Parr		1+ Smolt			2+ Smolt			
Year	Origin	No Mark	Ad Clip	No Mark	Ad clip	No Mark	Ad Clip	No Mark	Ad clip	Tagged	No Mark	Ad Clip	Tagged	Adults
1976-80[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1981	.	.	.	.	9,800	.	.	.	.	.	.	.	.	.
1982-90[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1991	Penobscot	51,025	.	.	40,001	.	.	.	60,205	.	.	.	.	.
1992	Penobscot	85,307	.	.	71,474	.	.	.	50,342	.	.	.	.	.
1993	Penobscot	.	.	.	100,950	.	.	.	40,110	.	.	.	.	.
1994	St. Croix	.	.	38,600	.	.	.	.	.	.	.	.	.	.
1994	Penobscot	87,200	.	.	.	.	.	.	60,600	.	.	.	.	.
1995	St. Croix	.	.	20,962	.	.	.	.	17,537	.	.	.	.	.
1995	Penobscot	400	.	.	.	.	.	.	.	.	.	.	.	.
1996	St. Croix	1,525	.	.	52,120	.	.	.	15,583	.	.	.	.	.
1996	Penobscot	364	.	.	.	.	.	.	.	.	.	.	.	.
1997	St. Croix	1,025	.	103,000	.	.	19,720	.	.	.	.	.	.	.
1997	Penobscot	1,236	.	.	400	.	.	.	.	.	.	.	.	.
1998	St. Croix	520	.	.	31,870	.	.	.	.	.	.	.	.	.
1998	Penobscot	1,553	.	.	.	.	.	.	.	.	.	.	.	.
1999	St. Croix	580	.	.	22,450	.	.	.	.	.	.	.	.	.
1999	Penobscot	1,406	.	.	.	.	.	.	21,314	.	.	.	.	.
2000	St. Croix	145	.	.	18,963	.	.	.	.	.	.	.	.	48
2000	Penobscot	1,266	.	.	.	.	.	.	19,984	.	.	.	.	702
2001	St. Croix	300	.	.	6,299	.	.	.	.	.	.	.	.	.
2001	Penobscot	834	.	.	.	.	.	.	8,146	.	.	.	.	524
2002	St. Croix	197	.	.	15,404	.	.	.	.	.	.	.	.	.
2002[b]	Penobscotb	.	.	.	.	.	.	.	4,147	.	.	.	.	.
2003	St. Croix	656	.	.	16,779	.	.	.	.	.	.	.	.	.
2003	Penobscot	215	.	.	.	.	.	.	3,232	.	.	.	.	.
2004	St. Croix	12	.	.	2,845	.	.	.	.	.	.	.	.	.
2004[b]	Penobscotb	.	.	.	.	.	.	.	4,098	.	.	.	.	.
2005	St. Croix / Tobique	.	.	.	24,815	.	.	.	.	.	.	.	.	.
2005[b]	Penobscotb	.	.	.	.	.	.	.	.	.	.	.	.	.
2006	St. Croix / Tobique	.	.	.	27,578	.	.	.	.	.	.	.	.	.
2007[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2008[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2009[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2010[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2011[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2012[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Total	.	**235,766**	-	**162,562**	**441,748**	-	**19,720**	-	**305,298**	-	-	-	-	**1,274**

Key:
[a] no releases.
[b] incomplete data - numbers not available.

Appendix 8. The individual criterion scores (0, 1, 2, or 3) for each river within OBoF to calculate the overall score that was used, along with geographic location, to set the priority rivers for DU 16. Period (.) equals no data.

River	1. Extirpation	2. Unique Traits	3. Density	4. Connectivity	5. Capacity	6. Threat impact	Score
Tobique R.	3	3	2	1	3	2	52
Canaan R.	3	0	3	3	3	3	48
Nashwaak R.	3	0	3	3	3	2	47
Hammond R.	3	0	3	3	2	3	46
Keswick R.	3	0	3	3	2	3	46
Kennebecasis R.	3	0	2	3	3	2	43
Shikatehawk Str.	3	0	3	2	1	2	40
Digdeguash R.	3	0	2	3	1	3	40
Nerepis R.	3	0	2	3	1	3	40
Nashwaaksis R.	3	0	2	3	1	3	40
Oromocto R.	3	0	1	3	3	3	40
Pocologan R.	3	0	2	3	1	3	40
Dennis Str.	3	0	2	3	1	3	40
Becaguimec Str.	3	0	2	2	2	3	39
Salmon R. Gr. Lk.	3	0	1	3	2	3	38
Little R. Gr Lk.	3	0	1	3	2	3	38
Gaspereau R. Gr. Lk.	3	0	1	3	2	3	38
Little Presquile Str.	3	0	2	2	1	2	36
Big Presquile Str.	3	0	2	2	1	2	36
Newcastle Cr., Gr. Lk.	3	0	1	3	1	3	36
Coal Cr., Gr. Lk.	3	0	1	3	1	3	36
Muniac Str.	3	0	2	2	1	2	36
Bellisle Cr.	3	0	1	3	1	3	36
New R.	3	0	1	3	1	3	36
Salmon R.	3	0	1	2	2	2	34
Portobello Cr. Gr. Lk.	3	0	0	3	1	3	32
Eel R.	3	0	1	2	1	2	32
Bocabec R.	3	0	0	3	1	3	32
Nackawic R.	3	0	1	1	1	2	29
Meduxnekeag R.	2	0	1	2	1	2	26
Shogomoc R.	1	0	1	2	1	3	21
Pokiok R.	1	0	1	2	1	3	21
Aroostook R.	2	0	0	1	1	2	19
Magaguadavic R.	1	0	0	2	1	1	15
Noonan Br., Gr. Lk.	0	0	0	3	1	3	14
Burpee Mill Str., Gr. Lk.	0	0	0	3	1	3	14
Cumberland Bay Gr. Lk.	0	0	0	3	1	3	14
Youngs Cove Gr. Lk.	0	0	0	3	1	3	14
Monquart Str.	0	0	3	0	0	2	14
Waweig R.	0	0	0	3	1	3	14
St. Croix R.	0	0	0	2	2	1	11
Mactaquac R.	0	0	0	2	1	3	11
River de Chute	0	0	0	2	1	2	10

Note: Removed Musquash.